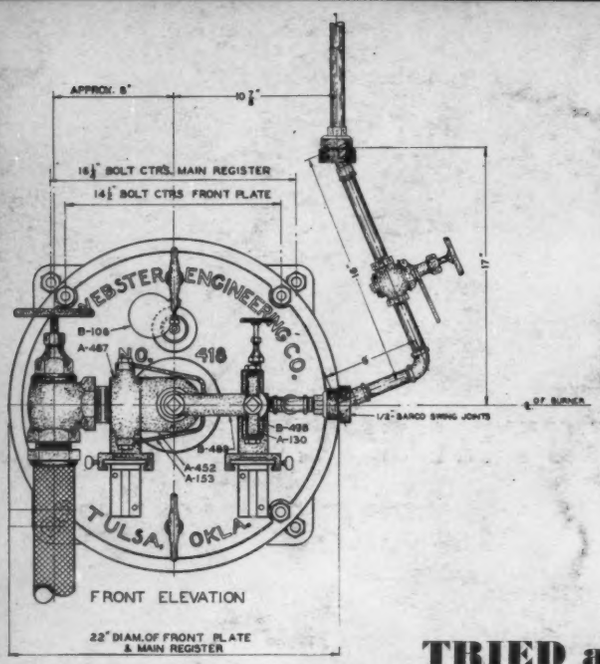


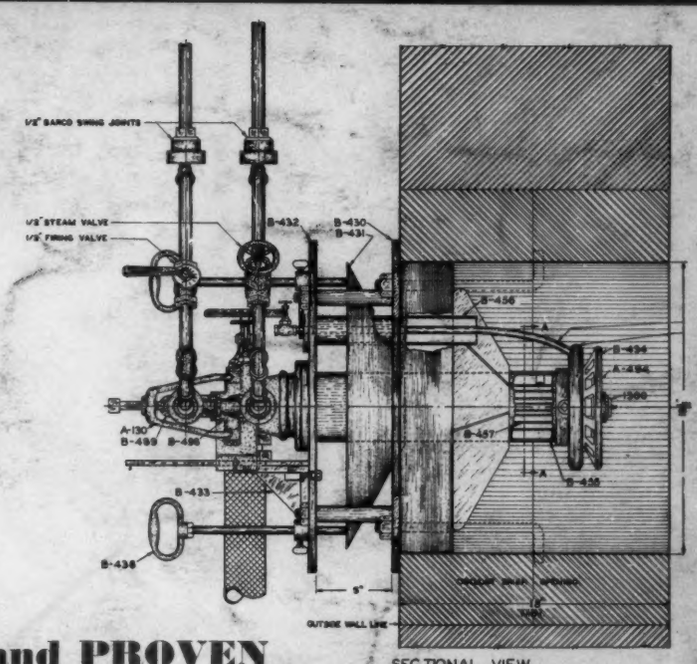

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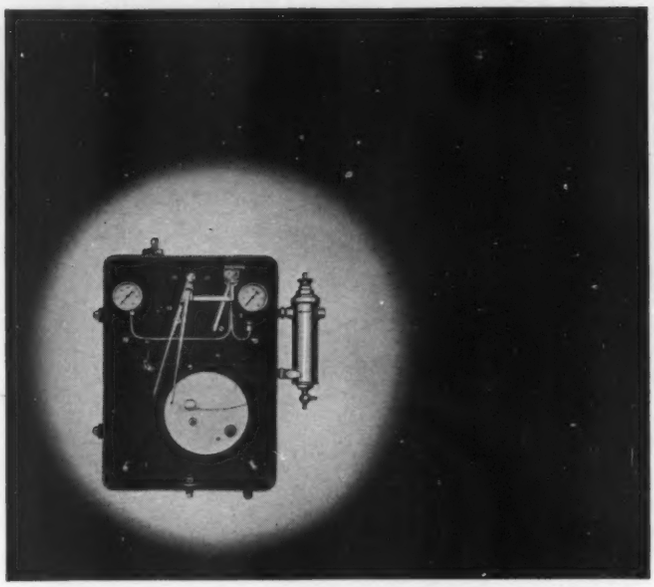

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# REFINER
## AND NATURAL GASOLINE MANUFACTURER

JANUARY, 1935
Vol. 14, No. 1

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*Copyright, 1935*

GEORGE REID
*Editor*


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VOLUME 14, No. 1 JANUARY, 1935

REFINER
AND NATURAL GASOLINE MANUFACTURER

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# The Look Box

***Obsolete*** The expected expenditures of the petroleum refining industry for 1935 ranges somewhere between $100,000,000 and $160,000,000—according to the varying estimates of various estimators who have recently oiled up their calculating machines and by devious routes arrived at conclusions of interest to refining concerns and manufacturers of equipment used in refineries; of interest, and it is hoped, of some value.

It is not contemplated that many new large refineries will be erected in this country, although it is anticipated that several will be erected in various foreign countries. It is not contemplated that there will be a wide spread wave of construction of the new and modern large capacity combination cracking systems, although it is expected that a reasonable number of such units will be erected. Likewise a reasonable number of highly efficient small capacity units for cracking will no doubt be installed. Rather, there will continue the steady flow of cracking unit facilities and equipment into the industry in virtually all sections of the country, a steady and important flow of materials and equipments which started during the later months of 1934. The same may be said of the installation of solvent extraction and solvent refining units, as there is certain to be a very important but consistent, slow but sure, conversion from older lubricating oil manufacturing methods over the period of the next two years.

What is confidently expected and what is certain to come unless every influence and condition now existing is entirely erroneous, and such is certainly not likely to be the case, is a wide spread, intensively active period of reconstruction, revamping, rehabilitation, modernization—a general and expensive move toward bringing facilities abreast of the times from an engineering and technical standpoint to secure that efficiency necessary for successful operation in a highly competitive and rapidly progressing scientific industry.

Obsolete facilities must give way. They must be discarded or relegated to other services where possible, making room for the efficiency available through application of processes developed in the light of modern knowledge and practice. The obsolete facilities extant are the chief contributing factor to the piling up of those expenditure figures quoted above.

In the distillation and cracking field it is estimated that 30 to 35 percent of the equipment is out-moded and obsolete and much of it is unsafe in its operation. About 30 percent of the present cracking equipment is around 10 years old and must be replaced. In the power plant field the refining industry is operating from 60 to 70 percent obsolete power generating facilities based on the fact that 25 percent of such facilities are 1 to 10 years old, 50 percent is 10 to 20 years old and 25 percent is older than 20 years. The trend in the power field is definitely toward installation of high pressure equipment.

In the field of lubricating oil manufacture it is thought that the advent and relatively rapid

adoption of solvent extraction and solvent refining processes brings about a condition where 65 to 75 percent of existing facilities may be declared obsolete. In the manufacture of greases 40 to 45 percent of the equipment is obsolete. In the field of gasoline recovery and stabilization modern progress renders approximately 40 to 45 percent of existing equipment obsolete. In the natural gasoline industry about 40 percent of present equipment is worn out, out-moded, corroded or obsolete. Indications are that present fractionation equipment in all branches of the industry soon may be slated for complete modernization and revamping and technical advancement now under way may prove much of our present fractionation facilities too inefficient for much longer service in such a competitive field.

Modernization programs will prove expensive. For the most part such work has been deferred so long that owners can not much longer operate plants without modernizing for modern efficiencies. Obsolete facilities can not much longer compete with newer processes and methods now available. And the older they grow the worse they get.

Obsolesence although of prime importance, is only one of the influencing factors which have aided the estimators to arrive at their expenditure figures. It, however, combined with some of the other obvious reasons, is sufficient to confirm the estimates.

***Optimistic Outlook*** Outstanding among the thoughts expressed in year-end statements on the oil situation is the note of optimism prevailing for the year 1935. This is the result of improvement during 1934, which places the industry in an excellent position for the coming year.

A number of factors have contributed in improving the statistical position of the industry, but most important are consumption increase, failure to discover new oil pools of large potential capacity, and better proration enforcement. The latter factor probably has been the most beneficial, and is due to application of the tender plan, which has practically stopped hot oil shipment. This has resulted in better marketing conditions during the last part of the year.

However, there are a number of important problems to be solved during 1935. Foremost of these is the program for permanent federal legislation. Another is the tax situation, which constantly is becoming more burdensome. Some 118 taxes are imposed on petroleum and its products now. The industry needs tax relief. Several legal problems upon which the present program is based also will be settled during the year.

But, there is every reason to believe that progress will continue during 1935, which will be an important year for the industry. Better conditions should mean greater profits, and a number of problems influencing the future course of the industry will be settled.

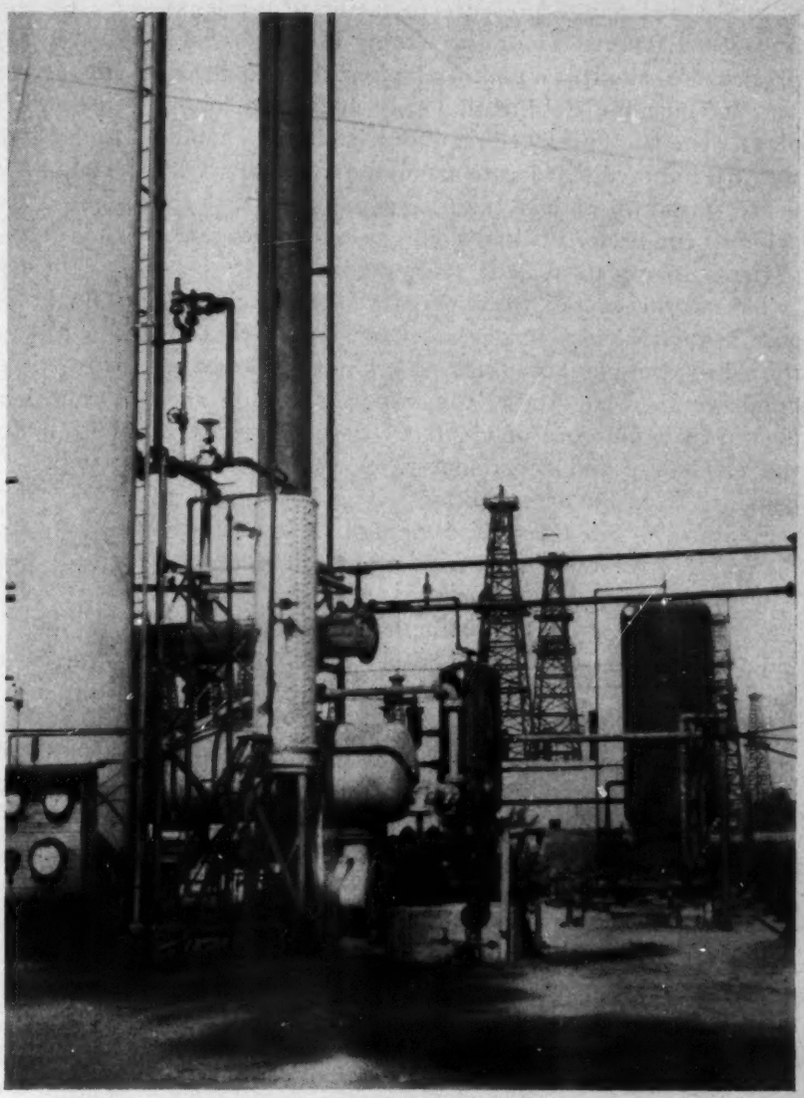
***This Issue*** In his discussion of salvaging of refinery wastes, L. C. Trescott is not talking about waste waters, chemicals, slops and the like. He is emphasizing the value of reclaiming valves, fittings, pumps, and many other important items of equipment. He includes data on organization of salvage departments, types of records to be kept and results to be secured, and the story is presented in such manner that it is interesting reading as well as of real value . . . I. N. Beall returns with Part 4 of his highly interesting and valuable series of articles on Elements of Stabilization, and it is an article of the type that many readers have been requesting . . . W. L. Nelson starts a three-part series of articles on Evaluation of Oil Stocks, Part 1, dealing with Classification of crude oils and methods of distillation . . . V. W. Garton and R. L. Huntington start a series of two articles on The Efficiency of Petroleum Fractionating Columns, Part 1 dealing with capacity and efficiency of laboratory packed columns . . . B. R. Bay discusses compressor station problems from the standpoint of site selection, design of plant, construction, auxiliary equipment and general operation problems. He knows his compressors and is well qualified to write of them . . . F. N. Wade from California presents an important discussion of the operating practices of West Coast refiners and natural gasoline manufacturers in the preparation of liquefied petroleum gases plants, giving both design and operating data . . . Design and operation of a new cracking unit at Allen, Oklahoma, is discussed.

***Next Month*** In the February issue in addition to continuation of the series of articles starting this month by W. L. Nelson and a series by V. W. Garton and R. L. Huntington, other discussions of importance will be presented . . . L. D. Wyant has prepared a valuable discussion relating to the practical considerations for the selection of refinery pumps. . . . A new stabilization and debutanization system operating in the Los Angeles Basin refining district will be presented . . . Gum in gasoline and the automobile engine is discussed by A. W.

(*Continued on page 25a*)

# California Practice in Production of Liquid Gas

H. N. WADE
*Parkhill-Wade, Inc.*



*Gasoline stabilizer and single-column liquid gas unit at a California absorption plant.*

THE last step in the production of marketable natural gasoline is the process of fractionating or "stabilizing" the raw gasoline produced by the absorption and distillation cycle, for the purpose of making a finished gasoline having desirable and uniform characteristics. The raw gasoline always contains small amounts of methane and ethane, and a considerable percentage of propane, all of which materials must be completely absent from the finished gasoline; in addition, most raw gasolines contain more iso- and normal butane than can be retained in the finished gasoline and still meet the usual market specifications for the product. The amount of propane in the raw gasoline usually varies between two per cent and 10 per cent of the raw liquid volume; the amount of excess butanes varies, according to fields, plant efficiency and required specifications of the finished gasoline, from nothing up to perhaps 40 per cent of the raw liquid. A fair average figure for the combined butanes and propane available from the stabilizer discard in a typical absorption plant is roughly 15 per cent of the finished gasoline production.

**THE available sources of liquid propane and butanes are, in the order of their present importance, natural gasoline plants, refinery vapor recovery systems, and cracking unit pressure-distillate stabilizers. Since the problems encountered in producing marketable liquid gases from any of these sources are similar in principle, this discussion will be limited to some typical methods which are in successful use at absorption plants.**

The most readily available material from which to produce liquid gas, then, is the discard from the stabilizer in a natural gasoline plant. The problem of converting this discard material into a marketable liquid gas is simply a fractionating problem, requiring the rejection of the methane and ethane, and the retention of all of the butanes, with enough propane to yield a mixture of the desired vapor-pressure characteristics. The operation is exactly like the operation of an ordinary gasoline stabilizer, except that the differences in the nature of the materials handled require widely different operating conditions of temperature and pressure.

For illustration, the accompanying flow-sheet Fig-

ure 1 shows the scheme of operation of one California liquid gas unit.

The conventional gasoline stabilizer is shown diagrammatically at the left. The column is operated at 200 pound gauge pressure to facilitate condensation of the discard vapor for making liquid gas; this pressure is about 35 pounds higher than is necessary for gasoline stabilization only at this particular plant. The back-pressure regulator is sized to handle the maximum discard rate from the stabilizer with a pressure-drop of less than 25 pounds, so that the primary condenser of the liquid gas unit can operate at pressures up to at least 175 pounds.

The warm vapors from the stabilizer back-pressure regulator pass through condensing sections to the "raw butane accumulator." Under reasonably good weather conditions the vapor is totally condensed at a pressure of about 150 pounds gauge in the condenser and accumulator. A vapor outlet is provided from the accumulator, with a back-pressure regulator set for 175 pounds gauge, to permit the escape of any vapor which may not be condensed, and thus avoid disturbing the stabilizer pressure. The accumulator is large enough to act as a surge-tank to smooth out short-period variations in the rate of make of the raw liquid, and is elevated a few feet to furnish adequate static head at the suction of the feed pump. A hand drain is provided for removing any water that drops out of the raw liquid.

The raw liquid is fed to the liquid gas fractionating column by a rate-controlled direct-acting steam pump, through the usual feed-to-product heat exchanger.

The fractionating column is designed for 275 pound gauge working pressure, and is provided with 30 bubble-cap trays. A steam-heated reboiler with temperature recorder-controller maintains the column base temperature constant. The column is fed on the middle plate. A pilot type level control maintains the liquid level constant in the base of the column The finished liquid gas product from the base passes from the heat exchanger through the level control valve and open after-cooling sections direct to the storage tanks.

The reflux and column pressure control system illustrated is of a simplified type, which is particularly adapted for producing a top-cut liquid product if desired. It requires only one small back-pressure regulator for maintaining the column pressure, and a level control for the reflux tank; yet open cooling sections are used for the reflux condenser and the system automatically adjusts itself to radical changes in cooling tower conditions.

Overhead vapor from the column in pipe (1) has two alternate paths, one through the condenser (4) into the reflux tank, and the other through float-controlled valve (2) direct to back-pressure regulator (3) and so out of the system. Condenser (4) is placed slightly lower than the normal liquid level in the reflux tank; hence valve (2) must throttle somewhat in order to force vapor through the condenser, the extent of the throttling being determined by the liquid level in the reflux tank. Since condenser (4) is "drowned", it fills up with liquid until the active surface remaining exposed to vapor is just sufficient to condense reflux at the rate required to hold the level constant in the reflux tank. The true discard passes continuously as warm uncondensed vapor direct to the back-pressure regulator; thus freezing of the regulator is avoided. The back-pressure regulator is directly responsive to the column pressure, and therefore the column pressure is not affected by slight changes in the pressure-drop through the reflux condensing system. Reflux is pumped back to the top of the column from the reflux tank by a rate-controlled direct-acting steam pump.

## OPERATING CONDITIONS

Following is a tabulation of operating conditions at this plant when making finished liquid gas mixtures showing Reid vapor pressures of 91 pounds and 125 pounds at 100°F.

| | Vapor Pressure of Product 91 lb. Reid | 125 lb. Reid |
|---|---|---|
| Column operating pressure | 235 lb. ga. | 240 lb. ga. |
| Base temperature | 176°F. | 149°F. |
| Top temperature | 112°F. | 108°F. |
| Raw accumulator pressure | 150 lb. ga. | 150 lb. ga. |
| Raw accumulator temperature | 70°F. | 70°F. |
| Molal reflux ratio, reflux-to-discard | 2.5:1 | 2.5:1 |

Fundamental analyses of the feed, product and discard when producing the 91 pound product developed the following material balance for 100 mols of feed:

### MOLS PER 100 MOLS FEED

| Component | Feed | Product | Discard |
|---|---|---|---|
| Methane | 2.13 | .... | 2.13 |
| Ethane | 5.32 | .... | 5.32 |
| Propane | 70.14 | 7.24 | 62.90 |
| Iso-Butane | 16.32 | 16.32 | ... |
| Normal Butane | 6.09 | 6.09 | ... |
| | 100.00 | 29.65 | 70.35 |

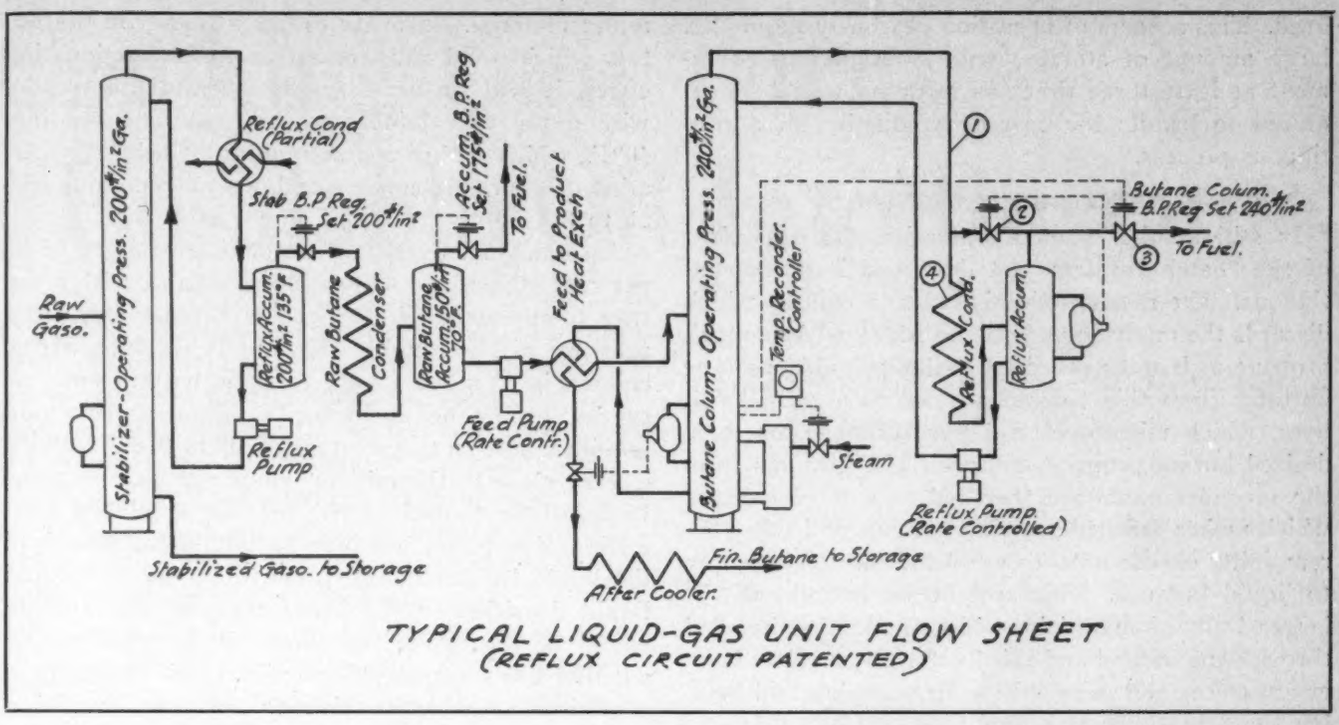
Expressed in terms of gallons per 100 mols of feed, this balance works out:

| Component | Feed | Product | Discard |
|---|---|---|---|
| Methane | 13.21 | .... | 13.21 |
| Ethane | 44.15 | .... | 44.15 |
| Propane | 719.90 | 74.30 | 645.60 |
| Iso-Butane | 202.00 | 202.00 | ... |
| Normal Butane | 73.00 | 73.00 | ... |
| | 1052.26 | 349.30 | 702.96 |

Thus the finished product under these conditions is 33.2 per cent of the raw feed, by liquid volume.

## MULTIPLE PRODUCTS

The plan of operation discussed above is a simple and efficient method of making well-fractionated butane-propane mixtures at plants where only one mix-




TYPICAL LIQUID-GAS UNIT FLOW SHEET
(REFLUX CIRCUIT PATENTED)

ture is desired at a time. Many producers wish to market several different grades of products at the same time. In such a case the use of the simple single-column unit described would require a very large amount of storage to accommodate each of the various grades, sufficient to meet all likely immediate demands. Also, while producing low-propane mixtures, a large amount of propane is necessarily discarded with a single-column unit, which propane may be at least partly marketable. Further, frequent changes would have to be made in the column operation, in order to keep the storage of the various grades in balance with the demand.

In order to obviate these difficulties, the following scheme of operating is in quite wide use, particularly at large plants. The discard from the primary gasoline stabilizer is condensed and fed to a primary liquid gas fractionator as described. This primary column is operated so as to produce the butanes only, without propane, as a bottom product. The overhead from this primary column is condensed and fed to a second column, which tops off the methane and ethane and excess of the propane, making a bottom product of pure propane. The pure cuts of butane and propane so produced are run to separate storage; with these two materials on hand the producer is prepared to furnish on short notice any desired butane-propane mixture by blending.

Several variants of this two-column scheme are in use. For example, a company making four or five standard grades of liquid gas, one or two of which represent the bulk of the output, may operate the first column to produce one of the popular mixtures directly as a bottom product; take pure butanes, or another mixture, from the base of the second column, and then use a third column to produce commercially pure propane.

Side-cuts taken from plates in the upper part of a column make it possible to produce more than one product from a single column. If substantially pure materials are desired, these side-cuts must be refractionated or "stripped" in small auxiliary columns with base heat, in order to remove unwanted lighter components. In general, the side-cut scheme is more difficult to control smoothly than the straight series column system, because the operation of the main column is affected by the amount of side-cut taken off, and also by the amount of heat put into the stripper if one is used.

### BATCH SYSTEM

One company which happens to have a surplus of storage and fractionator capacity produces a variety of cuts by "batching" through a single column. The raw gasoline is run continuously into raw gasoline storage tanks; the fractionation is handled as follows:

A batch of say 50,000 gallons of gasoline is run through the column, with conditions adjusted to take overhead all of the methane and ethane, and such amounts of propane as will not be needed later for making liquid gas. The partially stabilized gasoline from this first operation is run to storage, and is then rerun through the column, with conditions adjusted to take overhead pure propane, or any desired butane-propane mixture, which is condensed and run to liquid gas storage, the bottoms from the column during this operation being again run to storage. The gasoline is again rerun, making a bottom product to meet the required finished gasoline specifications, and taking the remainder of the excess butanes over-

head. This scheme of operation obviously requires a large amount of storage, with fractionating equipment at least three times as large as would be required to handle the current production in a continuous process.

### CONTINUOUS SYSTEM

In still another plan of operation the equivalent of the "batch" system just described is made continuous. The raw gasoline is fed to a column which discards the methane and ethane, along with as much propane as is not needed for making liquid gas. The bottoms from this column are fed to a second column, which takes overhead pure propane, or some desired butane-propane mixture. The bottoms from the second column are then fed to a third column, which makes finished gasoline bottoms and takes the remaining excess butanes overhead for condensation to liquid butanes. This system, on account of the larger bulk of materials which must be handled through the second and third columns, requires larger apparatus and more steam for pumping and heating than the other systems.

### UNFRACTIONATED STABILIZER REFLUX

In a few cases the liquid reflux over the primary gasoline stabilizer makes a marketable liquid gas mixture, without further treatment. This condition is most likely to be found in absorption plants which are equipped with efficient fat oil fractionating systems, which dispose largely of the methane, ethane and excess propane. In such plants the stabilizer discard is simply condensed and run to storage, with dehydration and chemical treatment for sulphur if necessary. The composition of such a product varies somewhat with weather and plant operating conditions, but it can be controlled within limits through manipulation of the fat oil fractionating system. This method of production, where applicable, is obviously the cheapest and simplest system of all.

### DE-ETHANIZING FRACTIONATOR

In the present state of development of the liquid gas market practically all plants produce naturally more propane than can be sold as such, hence every column in the unit can be operated to discard at least some considerable amount of propane. This makes it unnecessary to operate any column with a reflux of ethane and methane only, and therefore the highest column operating pressures can ordinarily be kept within not over 350 pounds gauge. As the market for liquid gas expands, the time will probably soon come when all of the easily-recoverable propane can be sold; it will then be necessary to design a fractionator to operate with a reflux of methane and ethane only. The design of such a column presents some interesting problems.

In the first place, the critical temperature of ethane is 93°F.; at this temperature the latent heat of the liquid is zero, and it would therefore be useless as a reflux material. In order to get a liquid on the top tray which could have some reasonable fractionating effect, it will be necessary to operate the column with a top tray temperature of not over possibly 40°F., which will of course require artificial refrigeration of the reflux condenser down to something like 25 to 30°F.

Assuming an overhead vapor composition of 65 per cent ethane and 35 per cent methane, with a top tray temperature of 40°F., the column operating pressure will be roughly 580 pounds absolute. If the column is to make a pure propane bottom cut (assuming no butanes in its feed), this pressure would require a bottom temperature of about 210°F., which is very close to the critical temperature of propane. Under these conditions the reboiler would be ineffective, due to its inability to put latent heat into the liquid in vaporizing it. Further, the vapor and liquid densities on the lower trays of the column would be practically the same; it is questionable whether the trays would function at all under these conditions. For de-ethanizing a mixture containing nothing heavier than propane it would therefore be necessary to drop the top tray temperature still lower, say to 10°F., requiring under the assumed conditions a column pressure of about 385 pounds absolute, and a base temperature of about 170°F.

### TREATING AND DEHYDRATION

Liquid gases originating from sulphurous stocks require treatment to prevent corrosion of the utilization equipment. In general, a simple caustic wash to remove hydrogen sulphide will be sufficient; small amounts of mercaptans will do no harm, and their presence makes artificial odorization of the product unnecessary. If mercaptans are present in excess, a hypochlorite treatment may be desirable; however, since this treatment does not actually remove sulphur from the material, but simply converts it into the form of sweet-smelling disulphides, its actual value in preventing corrosion of equipment is doubtful.

Dehydration of liquid gas products is desirable, especially when the material is used as "bottle-gas" for domestic installations. If a reasonable settling time is allowed, all but 0.02 per cent to 0.03 per cent of water will settle out in storage at ordinary temperatures. For some purposes even this small amount of water may cause trouble, and some type of chemical or adsorbent dehydrating agent must be employed. The material most commonly used for this purpose is silica gel. Passing the raw liquid gas from the primary column through a bed of coarsely granulated gel three or four feet thick thoroughly dehydrates it, and removes all possibility of the water interfering with the subsequent fractionating processes. The gel dehydrators are provided in duplicate, so that one can be dried out while the other is in operation.

# Cracking Unit Turns Unsalable Oil Into Revenue

F. L. MARTIN,[1] C. H. ALBERDING[2] and BERNARD J. FLOCK[3]

WAXY gas oil—about 1200 barrels per day—the by-product of a vacuum asphalt distillation, was the chief factor which led Sunray Oil Company to install the latest type Dubbs cracking unit in its refinery at Allen, Oklahoma.

This gas oil, taken overhead from the asphalt still and topping plant, was unsalable because of its high cold test due to an excessive paraffin content. It was a drag on the earnings of the plant.

The yield of gasoline from the crude was about 23 percent, the octane number was 64 to 68, and initial about 150. It was necessary to buy considerable quantities of natural gasoline to bring down the front end of the distillation curve.

F. L. Martin, vice president in charge of refining, was striving to place the refining department on a profitable basis, and after a careful study of the situation with the officials of the company, and the consideration of many proposals, it was decided that a Dubbs cracking unit was the best way to place the refinery on a competitive basis with other plants of its kind. On this basis a contract was signed with Universal Oil Products Company, the building of the unit was awarded to Foster Wheeler Corporation and construction began at once.

The unit was fired on August 20 and recently completed its first run of 42 days on stream. The unit met all performance guarantees and was accepted by Sunray Oil Company before the run was completed.

Sunray Oil Company has approximately 133 producing wells in the Allen field, a part of which were acquired in a merger with another company, along with a small skimming plant which consisted of a battery of shell stills of obsolete type. The first step in improving it after it was taken over four years ago, was the installation of a pipe still distillation unit built by Southwestern Engineering Company.

Later, beset by the low price of crude oil and other evils which harrassed the oil business generally, Sunray Oil Company officials tried to improve their position by putting in a unit to produce asphalt. A contract on this unit was awarded to Foster Wheeler Corporation and completed to a successful operation.

The asphalt found a market and brought a good price, but the gas oil proved too heavy a load to carry, the waxy content of this material being so high the price received for it was not profitable except through a cracking installation.

The Dubbs unit, designed to process 1200 barrels of fuel oil and the waxy gas oil, has solved the problem. This unit was so designed to process fuel oil or the overhead gas oil from the vacuum reducing still.

### DESCRIPTION OF EQUIPMENT

The unit was designed in accordance with the latest Dubbs full flashing principles, giving maximum flexibility for the vacuum overhead and fuel oil charging stocks available. At the same time simplicity of the arrangement and operation of the plant was maintained.

The equipment consists essentially of a furnace, reaction chamber, combination flash chamber and bubble tower, gas engine-driven hot oil pump, condenser, coolers, and the necessary pumps and auxiliary equipment.

The furnace is a Foster Wheeler single end fired radiant heat furnace. This furnace is divided into a convection and a radiant section.

The reaction chamber receives the material from the transfer line at the top and discharges all material at the bottom through a line discharging into the flash chamber section of the combination flash chamber and bubble tower.

The flash chamber and bubble tower are combined in one vessel. The vapors pass upward from the flash chamber section to the bubble tower section by means of a stand pipe. The charging stock is pumped into the bubble tower section and passes downward with the recycle stock into the combined feed reservoir surrounding the vapor stand pipe. Residuum is withdrawn from the bottom of the flash chamber section. The bubble tower section is equipped with 10 side to side pans and 16 bubble decks. A furnace oil side cut may be withdrawn from the bubble tower into a side cut stripper where the furnace oil is stripped, the vapors returning to the column. Gasoline vapors and gas pass from the top

[1]Sunray Oil Company.
[2]Universal Oil Products Co.
[3]Universal Oil Products Co.

of the bubble tower to the condenser and distillate receiver where the separation between gasoline and gas occurs.

The hot oil pump is a duplex plunger pump, driven by a two-cycle gas engine. This pump draws combined feed from the combined feed reservoir in the bottom of the bubble tower and discharges it directly into the furnace tubes.

The desired pressure is maintained on the reaction chamber by an automatic control valve in the bottom outlet of the reaction chamber. The pressure on the remainder of the system is controlled by the release of gas from the distillate receiver.

## CHARGING STOCK

The charging stock processed during the first run was an overhead from a vacuum reducing still in which the heavy fractions of the Allen crude oil are reduced to asphalt. A typical analysis of the charging stock is given in the following table.

| | |
|---|---|
| Gravity, °A. P. I. | 24.8 |
| B. S. & W., % | 0.0 |
| Cold Test, °F. | 100 |
| Flash Point, Clev. Open Cup, °F | 305 |
| Fire Point, Clev. Open Cup, °F | 405 |
| Viscosity, Saybolt Furol @ 122°F. | 26 |

**100 cc. Distillation**

| | |
|---|---|
| I. B. P. | 555°F. |
| 10% distilled over | 650°F. |
| 20% distilled over | 696°F. |
| 30% distilled over | 714°F. |
| 40% distilled over | 740°F. |
| % distilled @ 572°F. | 1.0 |
| % distilled @ 700°F. | 22.0 |

This analysis indicates the waxy character of the charging stock, which limits its use as a fuel oil without being thoroughly cracked. The cracking stock is high boiling throughout, having one percent distilling off at 572°F. and 22 percent off at 700°F.

## OPERATION

The operation during the first 31 days of the run was conducted so as to produce 400°F. end point gasoline and residuum. Typical results of this period are shown in the following table.

| | Barrels per day | Yields % by Vol. |
|---|---|---|
| Charging stock | 1455 | 100.00 |
| Gasoline | 775 | 53.19 |
| Residuum | 530 | 36.44 |
| Gas & loss | 150 | 10.37 |

The following analyses are representative of the quality of the gasoline and residuum produced.

**Gasoline**

| | |
|---|---|
| Gravity, °A. P. I. | 59.5 |
| I. B. P., °F. | 85 |
| 10% | 150 |
| 20% | 186 |
| 50% | 270 |
| 90% | 374 |
| E. P., °F. | 396 |
| % over | 95.0 |
| Octane No. C. F. R. M. M. | 69 |

**Residuum**

| | |
|---|---|
| Gravity, °A. P. I. | 10.5 |
| Flash point, Cleve. open cup, °F. | 175 |
| Fire point, Cleve. open cup, °F. | 310 |
| % B. S. & W. | 0.2 |
| Vis. S. F. @ 122°F., sec. | 90 |
| Cold test, °F. | 45 |

These results show the production of 53.19 percent of 396°F. E. P. gasoline of 69 octane number, motor method.

The fuel oil yield was 36.44 percent of a fuel oil meeting Bunker B. specifications. It is worth noting that the cold test of this residuum was 45°F., whereas the cold test of the charging stock was 100°F.

After 31 days on stream the operation was changed to produce a furnace oil distillate. The remainder of the run was conducted on this type of operation. A typical example of this operation is given below.

| | Barrels per day | Yields % by Vol. |
|---|---|---|
| Charging stock | 1942 | 100.00 |
| Gasoline | 795 | 40.95 |
| Furnace oil | 234 | 12.10 |
| Residuum | 726 | 37.40 |
| Gas and loss | 187 | 9.55 |

The properties of these products are shown in the following table.

**Gasoline**

| | |
|---|---|
| °A. P. I. | 60.9 |
| I. B. P. °F. | 82 |
| 10% distilled over | 140 |
| 20% distilled over | 174 |
| 50% distilled over | 250 |
| 90% distilled over | 358 |
| E. P., °F. | 380 |
| Octane No. C. F. R. M. M. | 72 |

**Furnace Oil**

| | |
|---|---|
| Grav., °A. P. I. | 35.7 |
| I. B. P. °F. | 381 |
| 10% | 406 |
| 20% | 416 |
| 50% | 438 |
| 90% | 466 |
| E. P., °F. | 510 |
| Cold test, °F. | 0 |

**Residuum**

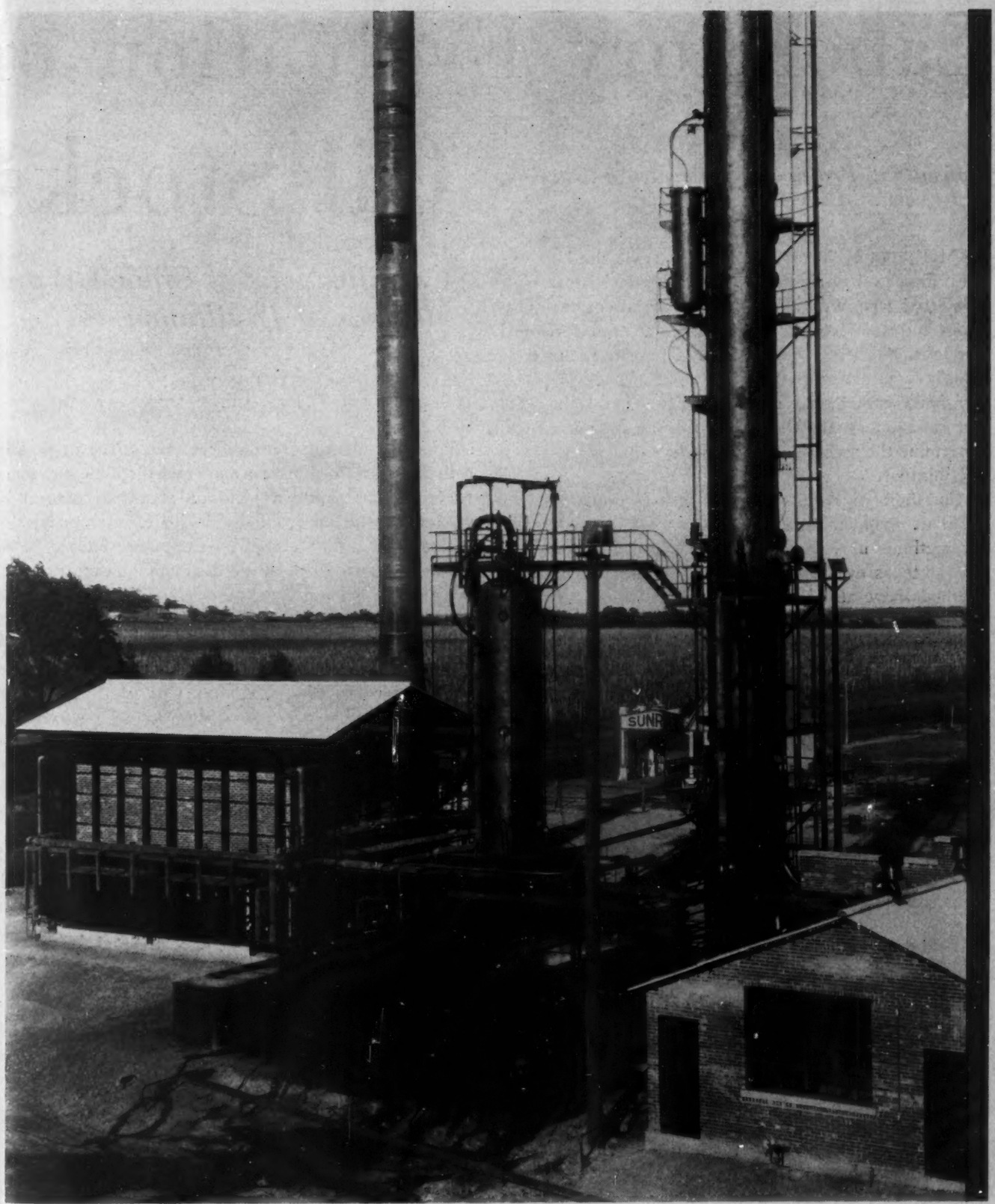
| | |
|---|---|
| Gravity, °A. P. I. | 11.6 |
| % B. S. & W. | 0.2 |
| Cold Test, °F. | 40 |
| Vis. S. F. @ 122°F., sec. | 59 |

The results of the operation during the whole on stream time are given in the following table.

| | Barrels per day | Yields % by Vol. |
|---|---|---|
| Charging stock | 1590 | 100.0 |
| Gasoline | 780 | 49.1 |
| Furnace oil | 61 | 3.8 |
| Residuum | 582 | 36.6 |
| Gas and loss | 167 | 10.5 |

The gasolines as produced from the unit are sweetened and treated with the Universal liquid inhibitor, which is giving satisfactory results.

All the above results were obtained under mild operating conditions. It is felt that after further runs are made, even the above results can be improved upon.




The quality of the products has been very gratifying in these operations and has placed Sunray Oil Company's gasoline and other products in a premium sales bracket. Especially is this true of the gasoline derived from this cracking plant, which is placed in the highest bracket selling for one to two cents more per gallon. This alone justifies this installation, and at the same time gives the company a product with the least sales resistance. Based on a 60 percent yield this cracking operation gives them 25 to 50 cents per barrel increased return on the finished products.

As further evidence of the flexibility of this installation, Allen crude oil is now being charged direct to the unit, giving a low cost operation. Gasoline of 375 E. P., a zero cold test side-cut distillate, and cracked fuel oil are the products produced.

# Laboratory Evaluation of Oil Stocks

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## *Classifications of Crude Oil and Methods of Distillation.*

**PART I**

THE routine laboratory tests that are used to examine oil products have been developed to a high degree of accuracy. Commercial specifications are numerous and satisfactory routine tests have been developed for most of these specifications. These tests are used mainly to ascertain the properties of finished (or partly finished) commercial products. In general they are not satisfactory for the analysis of an oil mixture to determine the amount of each product that is present in the mixture.

For the analysis of mixtures, such as crude oil, wax distillate, cylinder stock solution, tar, etc., special analysis methods must be used. These are commonly referred to as evaluation analyses. Evaluation analysis methods have also been developed to a high degree of accuracy but they have not been standardized because they are not as widely useful as routine tests. Each plant or company has developed evaluation tests independently and each plant has been loath to adopt the methods of another company without proof of the superiority of the new method. Nevertheless, the developments that have taken place in widely separated plants have been surprisingly alike. It is the purpose of these papers to discuss some of the evaluation methods that are being used.

### EVALUATION OF OIL STOCKS

The outstanding usefulness of evaluation analysis, is the facility that these analyses afford for the precise study of the economy of a processing operation. As an example, it is possible to ascertain the yield and properties of any of the common products that may be obtained from a raw stock, from a single complete evaluation analysis. The amounts of the several commercial gasolines, kerosenes, neutral oils, bright stocks, etc., may all be determined from a single complete set of evaluation curves. This affords an opportunity to study the economics of a plant operation rather than to indulge in expensive plant scale experiments with the stock.

In the past such information has been gained by plant experience. In other words, the plant management found over a period of years that certain yields of each stock could be obtained from a given crude. If the operation continued for many years they finally accumulated information on all of the crude oils that they were interested in. The results were conclusive enough but this method of gaining information is both expensive and tedious. In some cases the yields that were obtained by plant operation were even misleading. One refiner had been processing pressed distillate for many years and obtaining a yield of about 26 percent of viscous neutral oil from the distillate. An analysis of the pressed distillate showed that there should be 47 percent of viscous oil in the distillate. Year after year this refiner had failed to collect about 30 percent of his profits and the error was never recognized until a careful analysis of the stock was made. The shell still equipment that was used for redistilling the pressed distillate was decomposing a large part of it so that the yield of gas oil was large and the yield of viscous stock was small. The yield of 47 percent was actually obtained when a steam-atmospheric pipe still distillation unit was installed. Many similar examples may be cited. In this manner evaluation analyses may be used to determine the effectiveness of plant operations.

Many refiners evaluate their different crude oil stocks by the methods that are outlined herein. In this manner they can carefully select their crude oils and eliminate those oils that are least profitable. They can also select those oils that are particularly suited for lubricating oil manufacture and process these selected oils separately. Most refiners have done this in the past but without the precise knowledge of the value of their various stocks which a comprehensive analysis offers.

### CLASSIFICATION OF CRUDE OILS

The properties of a crude oil govern the properties of the products that can be produced from it. As an example, the characteristics of a lubricating oil can be closely estimated by noting the base of the crude oil that was used in its manufacture. Special treating and processing methods alter these inherent properties but normally the properties of the products are related to the properties of the crude oil. For this reason a thorough knowledge of the characteristic properties of the different bases of crude oil is necessary, if the value of a stock is to be wisely judged.

We are accustomed to referring to a crude oil as

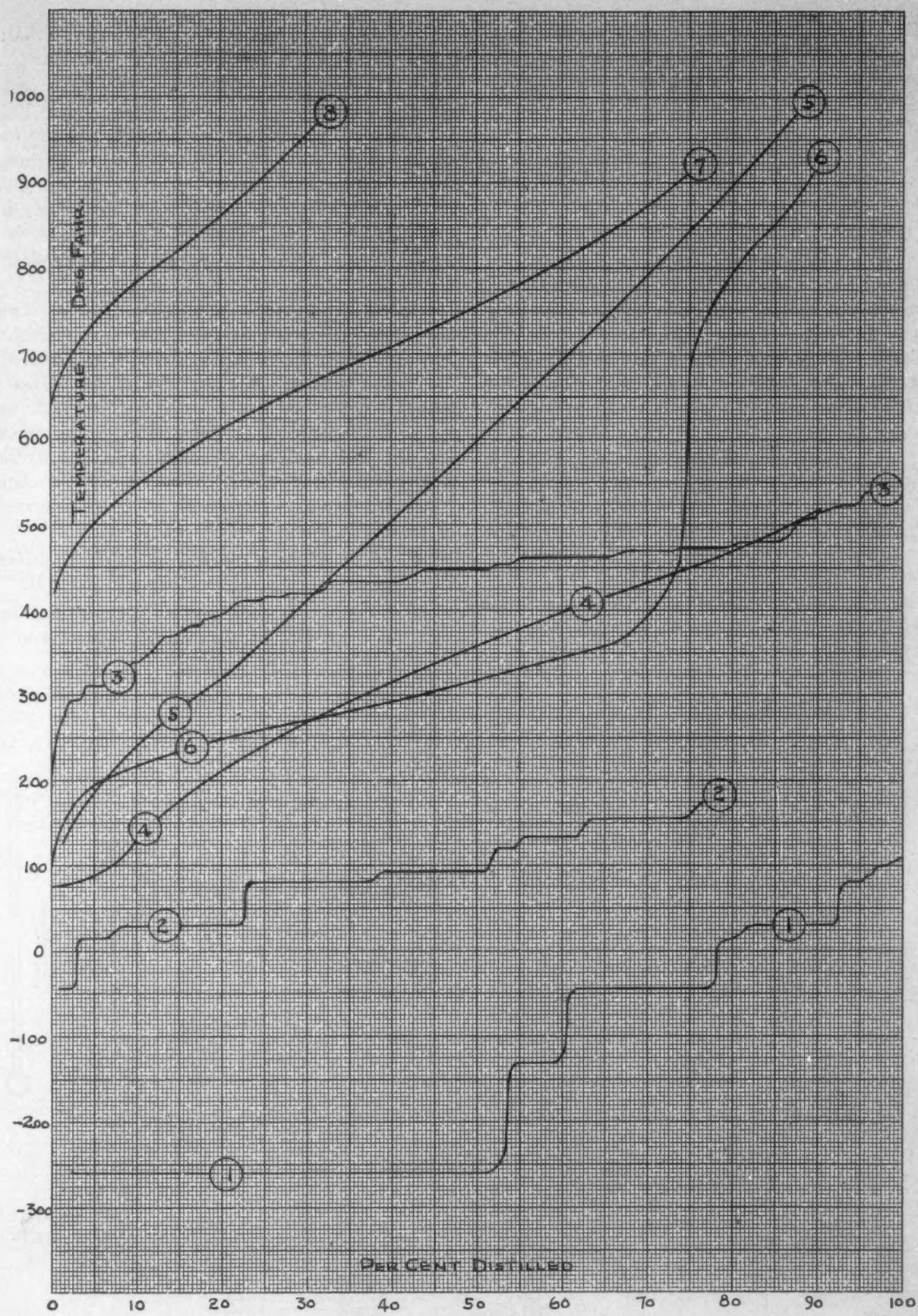


**FIGURE 1**

***True Boiling-Point Distillation Curves***

*Curve 1—Natural Gas—Low Temperature Fractional Analysis (Vol. percent of gas)*
*Curve 2—Natural Gasoline—Low Temperature Fractiona lAnalysis (Vol. percent of gas).*
*Curve 3—Kerosene—High Temperature Fractional Analysis.*
*Curve 4—Pipe Still Pressure Distillate—True Boiling-Point Equipment.*
*Curve 5—Mid-Continent Crude Oil—True Boiling-Point Equipment.*
*Curve 6—Bright Stock Solution—True Boiling-Point Equipment.*
*Curve 7—Mid-Continent Reduced Crude Oil—True Boiling-Point Equipment.*
*Curve 8—Semi-Solid Asphalt—True Boiling-Point Equipment.*

paraffin, mixed, or asphalt base, and yet there is no definite division line between these different oils. The oils that are referred to as mixed base, range in properties between paraffin base and asphalt base. That is, some of them are nearly the same as paraffin base oils and others have properties that are similar to those of naphthene base oils. Nevertheless, to experienced men, the base of an oil connotes certain distinctive properties.

The most common methods of determining the base of an oil will be discussed in detail:

(1) *Gravity and Gasoline Content*—There is no direct relation between the gravity of a crude oil and the amount of gasoline that it contains unless it is from a particular field or is a typical paraffin, mixed or asphalt base oil. However, crude oils may be generally classed as paraffin, mixed or asphalt base by means of Table I.

**TABLE I**

| A.P.I. Gravity | Percentage of Gasoline (410-425 E.P.) | | |
|---|---|---|---|
| | Paraffin Base | Mixed Base | Asphalt Base |
| 20 | none | rare | 5—30 |
| 30 | rare | 15—31 | 31 up |
| 40 | 20—34 | 34—58 | 58 up |
| 50 | 40—64 | 64 up | rare |

[1]Chem. & Met. Eng. 36:618 (1929) and O. & G. J. pg. 92, March 31, (1932.)

These data are presented in the form of a chart in Petroleum Engineer, April, 1931.

(2) *Viscosity Index*—The viscosity index is perhaps the most important property of an oil stock. This is due to the recent wide interest in high viscosity index lubricating oils. Paraffin base oils have high indexes (100+) and asphalt base oils have low indexes (0-30). The index can be improved by chemical treatment or solvent extraction and hence the viscosity index is not an indication of the base of the parent stock unless the oil has not been treated by special methods.

At a high temperature the viscosity of an oil is much lower than at room temperature. The rate at which oils loose their viscosity as they are heated, is measured by the viscosity index. The viscosity of low index oils decreases rapidly as the oil is heated but high index oils do not loose as much viscosity as the temperature is raised. Dean and Davis[1] proposed the viscosity index method of measuring the viscosity-temperature relations of oils and they have published a chart for determining the index.

The indexes of the lubricating oils from the different bases of crude oils are about as shown in Table II.

The viscosity index has assumed so great an importance that some oils, which in other respects would be

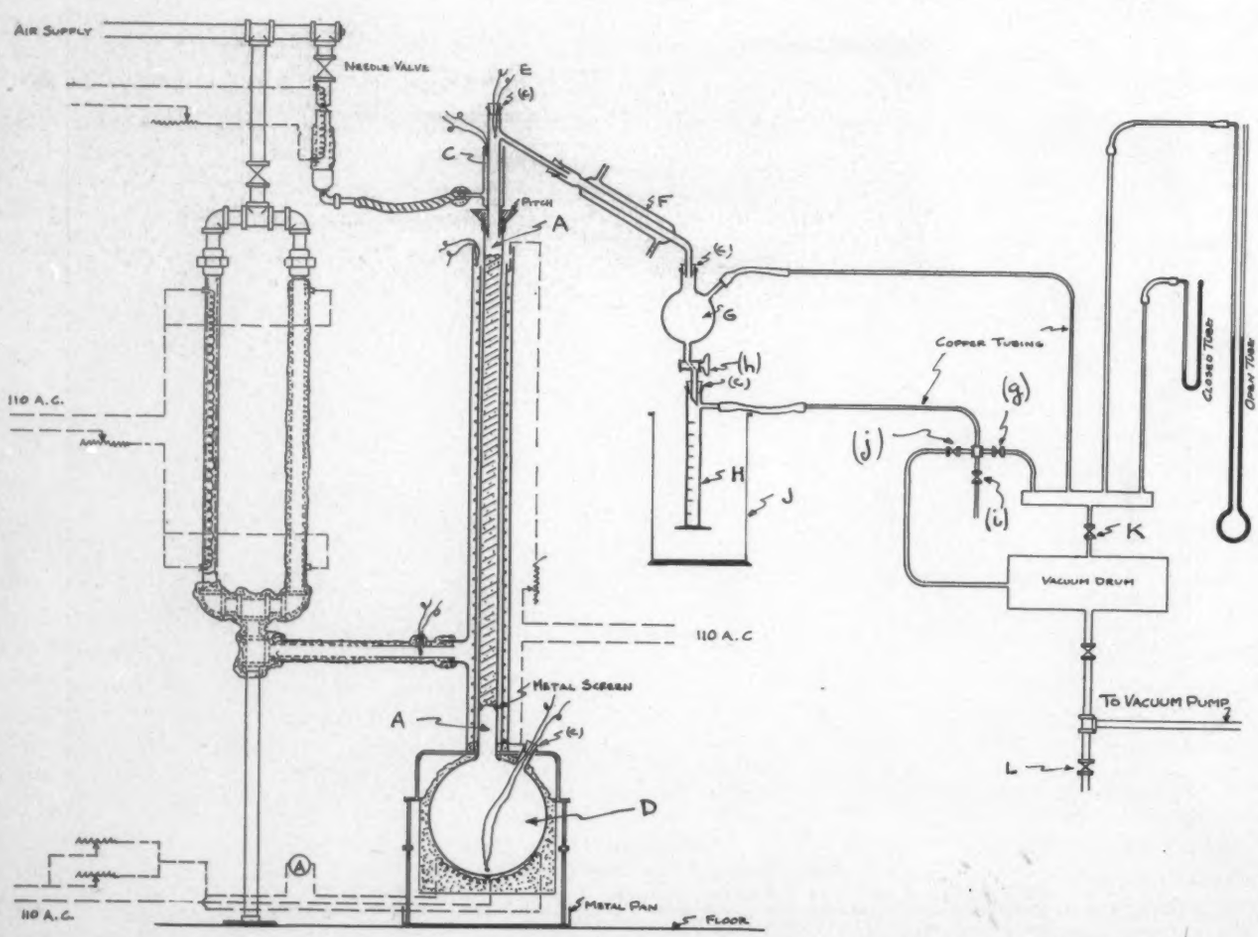


**FIGURE 2**
***Diagram of a True Boiling-Point Apparatus***

**TABLE II**

| Viscosity at 210° F. | Viscosity at 100° F. | | | Viscosity-Index | | |
|---|---|---|---|---|---|---|
| | Asphalt | Mixed | Paraffin | Asphalt | Mixed | Paraffin |
| 50 | 380 | 280 | 230 | 34 | 88 | 105 |
| 60 | 670 | 500 | 400 | 34 | 83 | 107 |
| 80 | 1500 | 1000 | 750 | 16 | 74 | 102 |
| 100 | 2300 | 1500 | 1130 | 23 | 78 | 102 |
| 150 | .... | 3200 | 2200 | .. | 78 | 103 |

classed as mixed base, are now classed as paraffin base because the index is high.

(3) *Viscosity—Gravity Constant*—The gravities (A. P. I.) of paraffin base oils are high and of the asphalt base oils low. This is a more consistent property than the viscosity index and hence another criterion, the viscosity gravity constant[2] has been developed. This constant may be determined from the viscosity at 100° F. and the A. P. I. gravity at 60° F. Thus, for light oils, the viscosity index can be obtained from the viscosity gravity constant without determining the viscosity at 210° F.

(4) *Key Fraction No. 1*—The portion of a crude oil that boils between 482 and 527° F. has been used to catalog crude oils. If the gravity of this fraction is above 40 A. P. I. the oil is paraffin base and if it is below 33 the oil is naphthene (asphalt) base. This method is involved in the viscosity gravity constant and also in Method (6), Table III. This method was developed by Smith of the United States Bureau of Mines[3].

(5) *Key Fraction No. 2*—This also was developed by the Bureau of Mines.[3] Key Fraction No. 2 boils between 527 and 572° F. at 40 mm pressure by the Bureau of Mines Hempel distillation method. This corresponds to a boiling range of approximately 733 to 779° F. (in wax distillate) at 760 mm pressure. If the cloud point of this fraction is below 5° F. the oil is naphthene (asphalt) base). Such a low cloud point means that for practical purposes, no wax is present.

(6) *Comparison with Oils of Known Base*—This method is necessarily a complicated one because it may involve a complete analysis. Nevertheless, it is by far the most reliable method and tells more than all of the other methods together. In fact, it involves most of the other methods that are mentioned above. Table III shows the average gravities of fractions of the different bases of oils. These were obtained from a comparison of many True Boiling Point Analyses (this method of distillation will be discussed later). Curves of the properties that are given in Tables III and IV were presented in Petroleum Engineer, April, 1930. In addition, a comparison of the boiling ranges of the different oils was given.

**TABLE III**
***Gravity Versus Boiling Point***

| Boiling Point of Narrow Fraction at 760 mm. | Gravity A.P.I. 60/60 | | |
|---|---|---|---|
| | Paraffin | Mixed | Asphalt |
| 200 | 68 | 66.5 | 66 |
| 400 | 48 | 44 | 43 |
| 600 | 39.5 | 33 | 28 |
| 700 | 36 | 29 | 23.5 |
| 800 | 33 | 26 | 20.5 |
| 900 | 30.5 | 23 | 18.0 |
| 1000 | 27.5 | 21 | .... |

For a given boiling point the asphalt base oils are much more viscous than the paraffin base oils. Thus,

[2]McCleur & Fenske, Ind. Eng. Chem. 24:1371 (1932.)
[3]Reports of Investigations Ser. No. 2806.

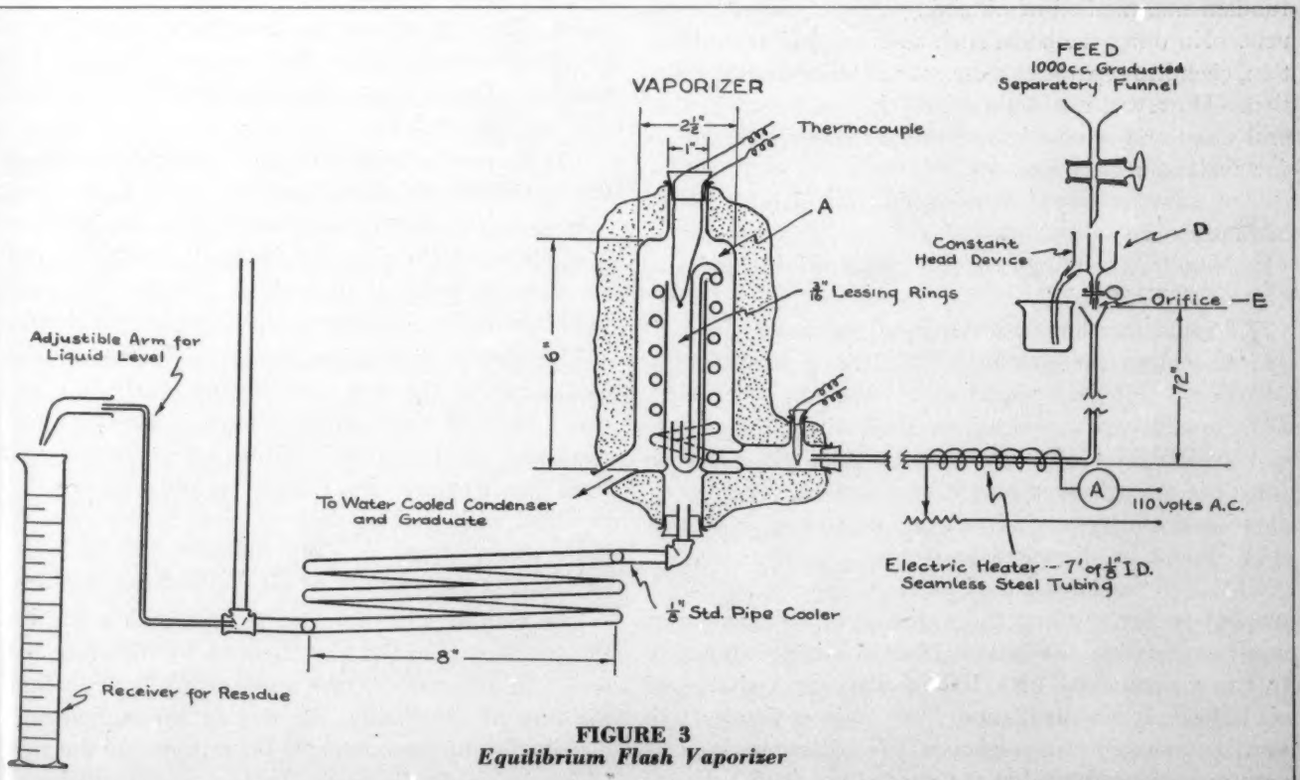


**FIGURE 3**
***Equilibrium Flash Vaporizer***

**TABLE IV**

***Viscosity of Fractions of Oil Versus Boiling Point***

| Boiling Point at Narrow Fraction at 760 mm. | Viscosity at 100 | | | Viscosity at 210 | | |
|---|---|---|---|---|---|---|
| | Paraffin | Mixed | Asphalt | Paraffin | Mixed | Asphalt |
| 600 | 40 | ... | 48 | ... | ... | ... |
| 700 | 65 | 75 | 115 | ... | ... | ... |
| 750 | 75 | 120 | 300 | 40 | ... | 49 |
| 800 | 120 | 240 | 700 | 45 | 49 | 65 |
| 850 | 180 | 480 | ... | 53 | 60 | 108 |
| 900 | 360 | 760 | ... | 62 | 75 | 190 |
| 950 | 600 | ... | ... | 77 | 100 | 350 |
| 1000 | ... | ... | ... | 100 | 150 | ... |
| 1050 | ... | ... | ... | 130 | 230 | ... |

a fraction that boils at 800° F. has a viscosity of 120, 240 or 700 if it is paraffin, mixed or asphalt base. This accounts for the much lower flash points of asphalt base lubricating oils. As a further example, consider a 30 SAE motor oil. This oil should have a viscosity of about 62 at 210° F. The average boiling point for such an oil if manufactured from paraffin mixed or asphalt base crude oils would be approximately 900, 860 and 790° F. Thus, the flash point of the asphalt base lubricating oil would be almost 110 degrees lower than the flash point of the paraffin base oil.

Another indication of the base from which an oil was produced is the "cast" or "bloom." The color of all distilled oils is yellow or red by transmitted light but by reflected light, regardless of color, the oil may exhibit a blue or yellow-green fluorescence at the surface. Asphalt base oils have a deep blue cast but paraffin base oils and even some mixed base oils have a yellowish cast. The natural yellow cast may be spoiled by improper acid treatment.

## METHODS OF DISTILLATION

In all methods for analyzing oil, distillation is the fundamental method of obtaining a separation of products. No other methods, such as fractional crystallization, chemical separations, etc., are as suitable as distillation. However, distillations may be conducted in several ways and some of them are far superior to others for evaluation purposes.

The common ways of conducting distillations in the laboratory are

(1) Non-fractionating or 10 percent distillation—A. S. T. M.
(2) Partial fractionation—Hempel distillation.
(3) Complete fractionation—True boiling point distillation.
(4) Equilibrium vaporization—flash distillation.

The first three of these are batch distillations but the fourth is a continuous type of distillation. The differences in these types of distillation are so important that they should be discussed in detail.

(1) *Non-fractionating distillation*—The A. S. T. M. distillation for gasoline and kerosene is an example of non-fractionating distillation although it is not necessary to use a small flask or a 100 cc charge. A charge of oil is heated in a distillation flask or in a simple flask that is connected to a condenser. No fractionating column or packing is used in the neck of the flask.

Little or no fractionation of the vapor occurs. The distillate that collects from the condenser is of nearly the same composition as the vapor that is generated in the flask. For evaluation purposes this manner of distillation is of little value. The distillation is unsatisfactory because the material that distills is a mixture and does not indicate the actual boiling range of the material. As an example the A. S. T. M. distillation of a gasoline may indicate an initial boiling point of 120 and an end point of 430° F. whereas it actually contains material boiling below 30° F. and material boiling up to 450° F. Further, the distillation curve of a gasoline is actually nearly a straight line, but the A. S. T. M. distillation always shows a marked curvature at both ends of the curve. Non-fractionating distillations cannot even be duplicated without carefully specifying all of the details of the procedure. Note the procedure of the A. S. T. M. distillation for an operation that is carefully regulated. This regulation is necessary in a non-fractionating distillation.

This criticism of the A. S. T. M. distillation for evaluation purposes does not infer that the A. S. T. M. is of no value. The A. S. T. M. distillation serves a valuable purpose and it is just the kind of a distillation that is needed for specifying commercial products and for governing plant operation. For these purposes it is more useful than the other methods which will be discussed later.

Crude oils are sometimes analyzed for the content of gasoline and kerosene by non-fractionating distillations but the analyses are practically worthless. The material boiling to 400° F. by such a distillation is often referred to as gasoline but the amount of gasoline by such a method is usually in error by more than 15 percent. The only reason for continuing to conduct such inadequate distillations is that they are simple and inexpensive. The simplest laboratory is usually equipped to run such an analysis.

(2) *Hempel distillation*—The Hempel distillation is not an entirely satisfactory method but it is far superior to a non-fractionating distillation. In the hands of a competent oil chemist, the Hempel distillation can be an accurate method of analysis. It has been widely used because the equipment and procedure is simple.

The Hempel distillation may be conducted in the same equipment as the non-fractionating distillation except that a Hempel fractionating column is used between the flask and the condenser. The full size Hempel column head has a space about eight inches long which can be filled with packing such as glass beads, glass chips, brass chain or gauze. The diameter of the head depends upon the quantity of oil that is being distilled.

The trouble with the Hempel distillation is the fact that different results are obtained by different operators. In other words, the temperature is dependent on the rate of distillation, the size of the equipment, the distribution of compounds in the sample and the amount of insulation that is used. In fact, the Hempel method

cannot be used successfully for high-boiling materials unless a part of the column and flask is insulated to reduce condensation. These difficulties arise to some extent, with all column head types of distilling systems. In the past many types of column heads[4] were investigated but they all have the same general disadvantages as the Hempel column and they are not widely used.

If a Hempel distillation is stopped at 400° F. for the evaluation of gasoline, the end point of the distillate may range from 395 to 420° F., depending upon the skill of the operator. Some laboratory men have become so skillful that the Hempel cut point is the same as the A. S. T. M. end point. This has been pointed to with pride, as an indication that the Hempel method is a superior one. To have the cut point and the A. S. T. M. end point the same, is convenient but few laboratory men are able to conduct a Hempel distillation in this precise manner. The fractionation that is obtained in a Hempel distillation is not as good as the fractionation in a modern fractionating tower and hence the Hempel distillation does not duplicate the yields that are obtained in plant operation. However, it is much better than a simple non-fractionating distillation and it is adequate for many purposes.

(3) *True Boiling Point Distillation*—For truly dependable results some form of fractionating distillation must be used. In this paper the term "true boiling point" is used to refer to any equipment that produces excellent fractionation, as well as the particular equipment that is described herein. Many different types of equipment are being used but except for minor differences they all produce about the same results. Some of these depend upon insulation or electrical heating elements to maintain the proper temperature in the fractionating column, others utilize an evacuated jacket and mirrored surfaces to reflect radiation and the equipment described herein utilizes an air jacket which can be heated to the proper temperature. The true boiling point equipment that is described herein and as shown in Figure 2 has been successfully used at the University of Tulsa and by many engineering and oil companies.

A satisfactory evaluation analysis for plant operation and design purposes must meet certain requirements. The most important of these are

(1) The results must represent yields and properties that can be duplicated in a modern, properly operated commercial equipment.

(2) The procedure of analysis must be such that the results can be duplicated.

(3) The data should be general in nature, if that is possible, so that many combinations of yields can be computed from a single analysis.

(4) The equipment must produce large enough fractions for the routine tests of viscosity, gravity, flash-point, etc.

(5) The cost must not be excessive.

The true boiling point distillation meets these requirements and a fractionating distillation is always a part of any dependable evaluation.

In fractionating types of distillations, the hydrocarbons that are vaporized are sorted, one by one, and arranged in the order of their boiling points. The Podbielniak low temperature equipment for analyzing natural gas and gasoline separates the hydrocarbons almost perfectly. Refer to Figure 1. Other equipments, including the true boiling point equipment, probably do not cause as perfect a separation. Nevertheless, for practical purposes the separation that is obtained in other equipment is satisfactory and even preferable to a perfect separation. A perfect separation is not desirable because petroleum mixtures are very complex and the chemist and designer would not know how to handle the large number of components that a perfect fractionation gives. Curve 3 in Figure 1 shows a nearly perfect fractionation of kerosene. A designer or plant engineer would be at a loss to know what to do with such an analysis. However, it would be valuable for research work. Figure 1 shows typical fractional analyses of refinery products. Some of these were obtained on the Podbielniak high and low temperature distillation equipment[5] and others on the true boiling point equipment described herein.

The true boiling point equipment, Figure 2, was first described by Peters & Baker[6]. The success of the equipment is due to the maintenance of adiabatic conditions in the fractionating column. The outer jacket A, through which heated air flows,is kept at substantially the same temperature as the vapor within the column, so that no heat passes into or out of the fractionating column. Since no heat is gained or lost by the column, the amount of reflux, or cooling material that is introduced into the top of the column by the reflux air jacket C, is dependent only upon the composition of the vapor from the flask and the degree of separation desired. Thus, the column is not subject to fluctuations in the conditions of the environment such as room temperature and draughts of air or to fluctuations in the rate of heating in the flask D. The disturbing influence of changing room conditions is particularly important in the operation of laboratory equipment because the heat losses are often larger than the useful heat input.

The heating flask D (Figure 2) ranges in capacity from 1000 to 5000 cc. The larger still is convenient for evaluation analyses of heavy stocks because fractions of 100 cc each are necessary for subsequent tests. The vacuum pump should have a capacity of two to six cubic feet per minute depending upon the capacity of the still. Heat is supplied by electrical resistance coils, throughout the apparatus. The vapor mixture ascends the adiabatic column A, and at the top it is cooled by the reflux air jacket C so that most of it condenses and is returned to the column as reflux. The purified vapor

[4]Leslie—"Motor Fuels," Chap. XV Chem. Catalog Co. (1923.)
[5]Ind. Eng. Chem. Anal. Ed. 3:177 April 15 (1931) also 5:119 (1933) and 5:135 (1933.)
[6]Ind. Eng. Chem. 18:69 (1926.)

passes the thermocouple E in the column head and is condensed in the water or air cooled condenser F.

The temporary receiver G is for operation at a reduced pressure. During vacuum distillation the product normally drips through G into the graduate. When the graduate H is full, the stop-cock (h) and the cock (g) are closed and the graduate is removed by venting to the atmosphere through cock (i). An empty graduate is placed in position and the cock (j) is slowly opened so that the vacuum on the main system is not greatly disturbed. After the new graduate has been evacuated, cock (j) is closed and the cocks (g) and (h) may be opened. Throughout the operation of changing the graduate, the pressure regulation valve K should not be touched.

The distillation may be conducted in two ways; either at a constant rate of distillation or at a variable rate. Distillation is usually conducted at a constant rate but the variable rate of operation seems to be the best. However, for analyzing plant operation or design, the constant rate method whereby a smooth distillation curve is obtained, is more convenient. The variable rate method gives steps in the distillation curve (each step a pure component) and the curve cannot be easily used. In the variable rate method, the rate of distillation is governed by the amount of material that boils at each temperature. If the amount of material that boils at a given temperature is large, then the rate should be fast, but if only a small amount boils at the temperature, the rate should be slow so that a higher reflux ratio is used. The curves in Figure 1, by the Podbielniak equipment, were obtained by using a variable rate of distillation.

(4) *Equilibrium vaporization*—The three methods that have been discussed were all batch operations. In equilibrium or flash vaporization, the charge stock is continuously fed into the equipment and the vapors are not allowed to separate as they are produced but are kept in contact with the remaining liquid until the final vaporization temperature is attained. Distillation in a pipe still and fractionating tower is an exact duplication of this method of vaporization. Equilibrium must be established between the vapor and liquid at the outlet of the heating coil (Figure 3) but equilibrium is easily established. Even a splash plate seems to be sufficient mixing to cause equilibrium.

Figure 3 is a sketch of a successful laboratory equipment for determining equilibrium flash vaporization data. It is satisfactory for crude oils and distillate materials but it is not suited to operation at a vacuum. Flash vaporization equipment performs satisfactorily if the rate of feed can be accurately controlled and if a constant outlet temperature can be maintained. The apparatus shown in Figure 3 is not as exact as other

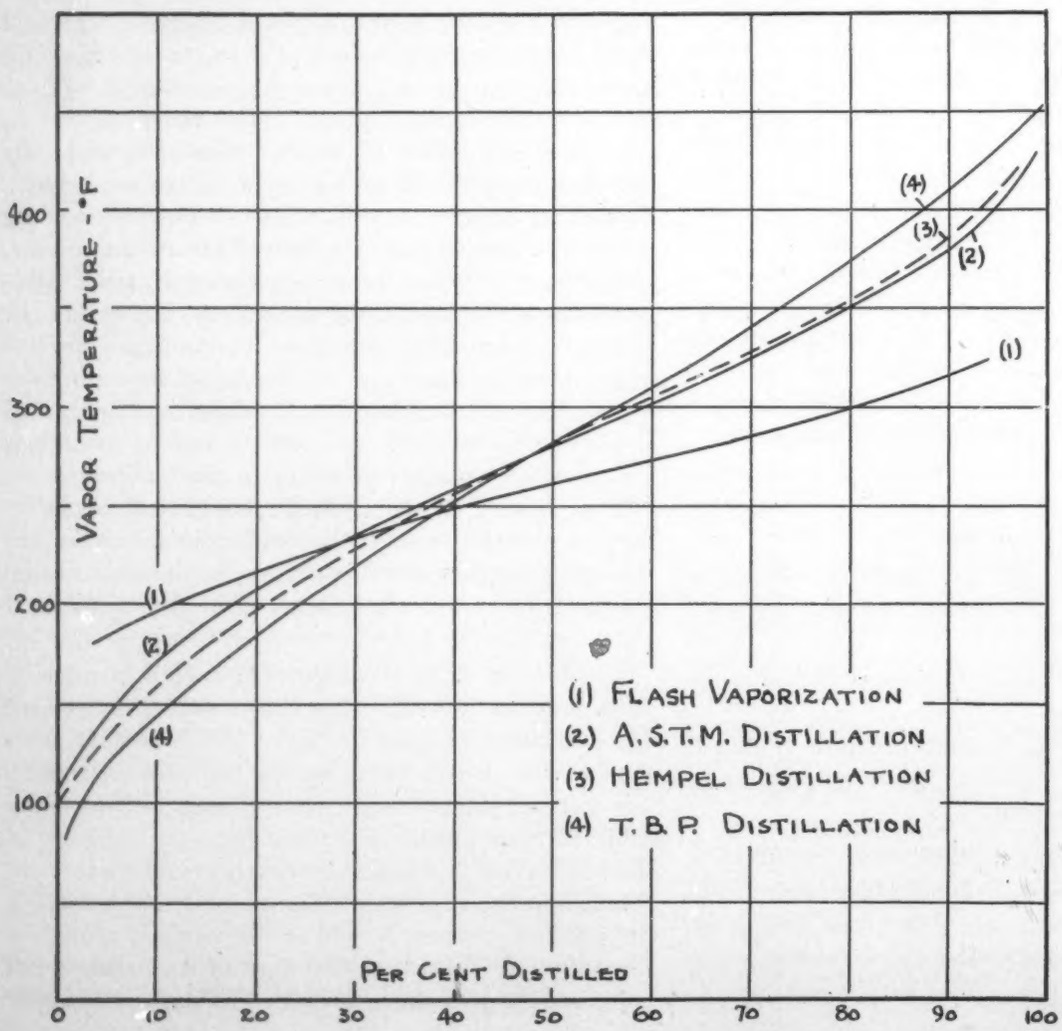


**FIGURE 4**
***Vapor Temperature Curves***

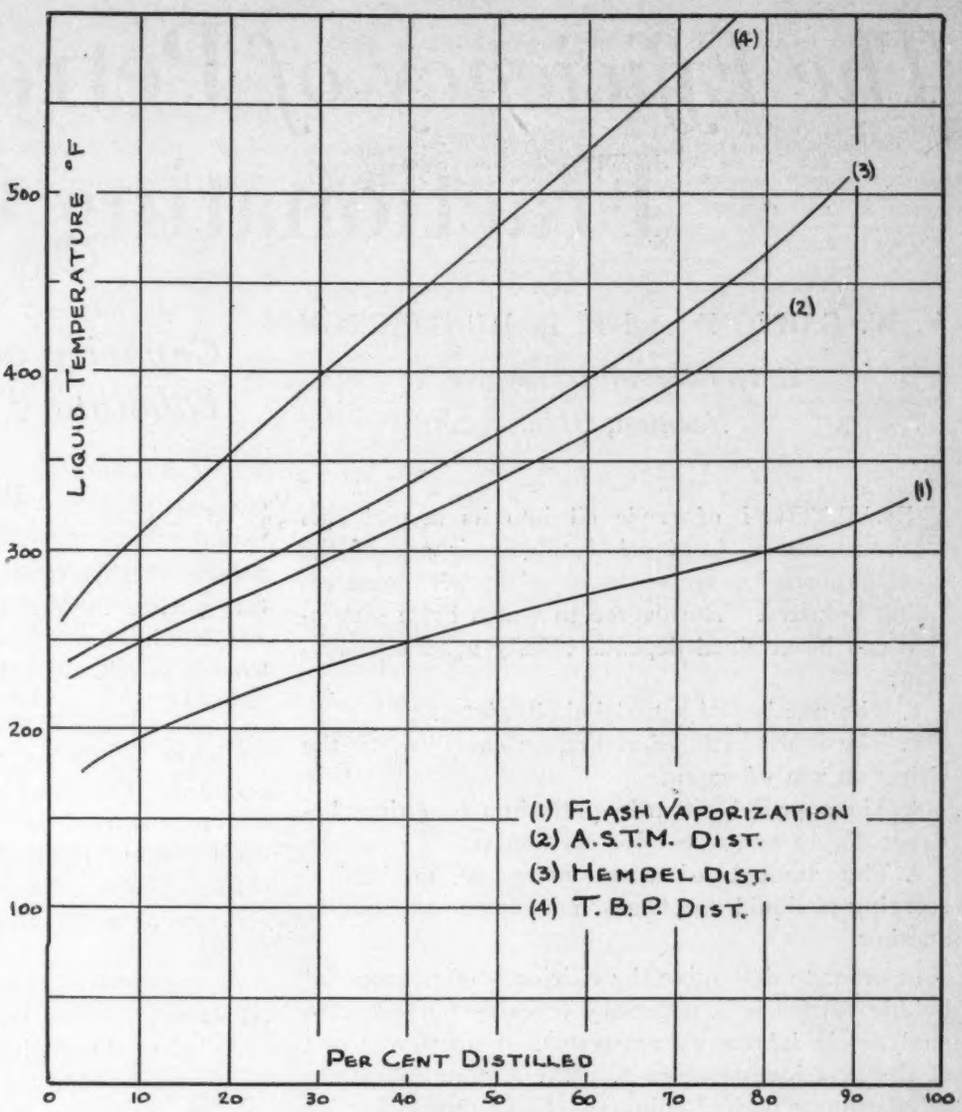


**FIGURE 5**
***Liquid Temperature Curves***

equipments[7], [8] but it is sufficiently accurate for most plant work. The more exact equipments[7], [8] consist of a large bath which keeps the heating coil and vaporizer to within ±0.5° F. of the desired temperature. The objection to such equipments for commercial work is the length of time required to complete an analysis and the expense.

In the equipment shown in Figure 3 the rate of feed is regulated by the constant head device D and the orifice E. The vaporizer A, packed with Lessing rings, is used to establish equilibrium. In determining the flash vaporization curve, several runs or tests must be conducted. The oil is allowed to flow through the equipment until the vaporizer temperature is constant and the amount of vaporization is constant. The run is then conducted for a measured length of time and the percentage of vapor and of liquid is measured. This constitutes a single point on the curve and several points must be determined in this manner to draw the entire flash vaporization curve.

## TEMPERATURE TO DISTILL

The temperature to which a stock must be heated in order to vaporize a given percentage is important to the plant engineer or operator. Flash vaporization (method 4) requires the lowest temperature and fractional distillation (method 3) requires the highest temperature. The vapor temperatures that were obtained when distilling a Mid-Continent pressure distillate by the four methods of distillation are shown in Figure 4.

However, the liquid temperature is of more importance to the plant operator than the vapor temperature. The liquid temperature curves that correspond to the four distillations that are shown in Figure 4 are plotted in Figure 5. Here, the great superiority of flash vaporization, over the batch methods of distillation, is evident. Without flash vaporization (pipe stills and towers) the modern processing operation of vacuum distillation could never have been developed.

[7]Leslie & Good—"The Vaporization of Petroleum," Ind. Eng. Chem. 19:453 (1927.)
[8]Piromoov & Beiswenger—"Equi. Vaporization . . ." Am. Pet. Inst. Bull. 10, No. 252 (1929.)

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# *The Efficiency of* Petroleum Fractionating Columns

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***University of Oklahoma***
***Norman, Okla.***

## *Capacity and Efficiency of Laboratory Packed Columns.*

### PART I

SEPARATION of crude oil into its several cuts by means of fractional distillation is one of the most important processes used in the petroleum refining industry. The degree to which close separation can be attained depends chiefly upon four factors:

1. The number of actual bubble plates.
2. The molal ratio of reflux, or overflow, to the rising stream of vapor.
3. The approach toward equilibrium conditions between liquid and vapor on each plate.
4. The amount of entrainment or mechanical carrying of liquid droplets or mist from one plate to another.

In order to determine the efficiency of commercial bubble towers it is necessary to carry out accurate analyses in laboratory apparatus. Peters[8] was one of the first investigators to make a thorough study of laboratory packed columns. Since then other investigators[1 2 3 4 5 6 9] have done much work both on packed and bubble plate towers. The laboratory column described in this paper is similar to those used by previous workers[3 4 1]. The purpose of this present study was to develop a simple method of determining the fractionating capacity of any laboratory packed column, a knowledge of which is essential in the analysis of fractions from commercial towers, and in the calculation of their efficiencies.

#### EXPERIMENTAL APPARATUS

Figure 1 shows two laboratory fractionating columns. The column to the right is a Podbielniak low temperature apparatus for the analysis of natural gas and natural gasoline, while the taller column in the left foreground is one designed for the separation of crude oil and heavier petroleum fractions.

A diagrammatic sketch of this high temperature laboratory column is shown in Figure 2. Heat is supplied to the distilling flask by means of an electrical resistance located just below the flask, and the column is heated by means of a Nichrome wire wound spirally around it from top to bottom. The insulated box around the distilling flask and the flanged jacket around the column are readily removable. Several small openings have been provided at different points in the column jacket so that compressed air may be blown through the hot air space

*Present Address—Gulf Refining Company, Port Arthur, Texas.

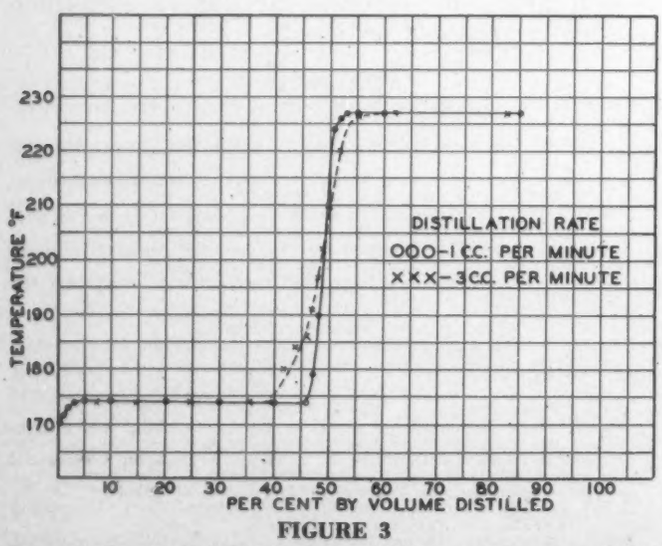


**FIGURE 3**

***True boiling point distillation of Benzene-Toluene mixture***

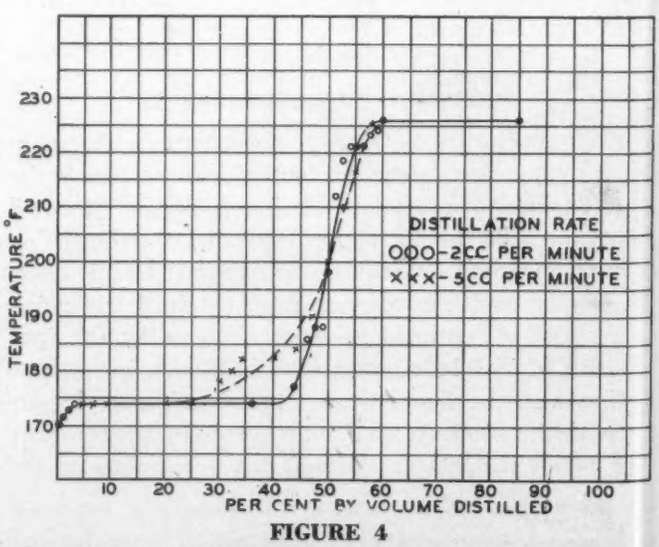


**FIGURE 4**

***True boiling point distillation of Benzene-Toluene mixture***

whenever it is desirable to remove heat from the column quickly.

The tower is packed with pieces of thin walled glass tubing about one fourth-inch in diameter and one half-inch in length. This packed section is 57 inches in length and 1¼ inches inside diameter. The entire distillation assembly is made of pyrex glass. Two vacuum pumps make it possible to maintain a high vacuum on the system during the entire period required for the distillation of the fractions boiling above 450°F.

### DETERMINATION OF THE NUMBER OF THEORETICAL TRAYS IN THE PACKED COLUMN

Known mixtures of benzene and toluene were distilled at different rates in order to compute the number of theoretical trays in the column. The results of these experimental distillations are given in Figures 3 and 4. In Table I these results are shown in weight and mol percentages as well as volume percentages. In arriving at the percentage of the more volatile constituent in the distillate, the percentage boiling between the respective benzene and toluene plateaus was divided by two. By means of the McCabe-Thiele[7] method, the separation of a binary mixture of hydrocarbons may be analyzed graphically. These diagrams are shown in Figures 5, 6, 7, and 8. Since the ratio of internal reflux to vapor

**TABLE 1**
**Data on Distillation (50%-50% by volume) Mixtures (Benzene and Toluene)**

| Distillation Rate cc. per Minute | % by Volume Toluene in Distillate | % by Weight Toluene in Distillate | Mol. % of Toluene in Distillate | % by Volume Toluene in Bottoms | % by Weight Toluene in Bottoms | Mol. % of Toluene in Bottoms |
|---|---|---|---|---|---|---|
| 1..... | 3.00 | 2.96 | 2.52 | 97.00 | 96.80 | 96.25 |
| 2..... | 7.50 | 7.40 | 6.43 | 92.50 | 92.30 | 91.00 |
| 3..... | 10.50 | 10.35 | 8.98 | 89.50 | 89.30 | 87.64 |
| 5..... | 18.50 | 18.25 | 15.90 | 81.50 | 81.30 | 78.60 |
| | % by Volume Benzene in Distillate | % by Weight Benzene in Distillate | Mol. % of Benzene in Distillate | % by Volume Benzene in Bottoms | % by Weight Benzene in Bottoms | Mol. % of Benzene in Bottoms |
| 1..... | 97.00 | 97.04 | 97.48 | 3.00 | 3.20 | 2.75 |
| 2..... | 92.50 | 92.60 | 93.57 | 7.50 | 7.70 | 9.00 |
| 3..... | 89.50 | 89.65 | 92.04 | 10.50 | 10.70 | 12.36 |
| 5..... | 81.50 | 81.75 | 84.10 | 18.50 | 18.70 | 21.40 |

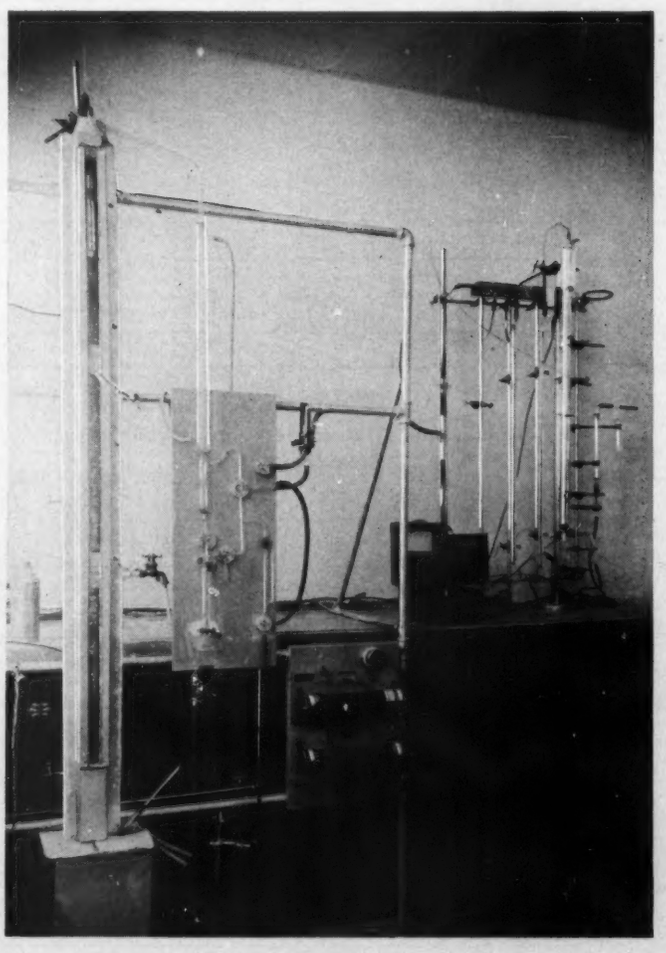

**FIGURE 1**
***Left to right: High temperature true boiling point column and Podbielniak low temperature column***

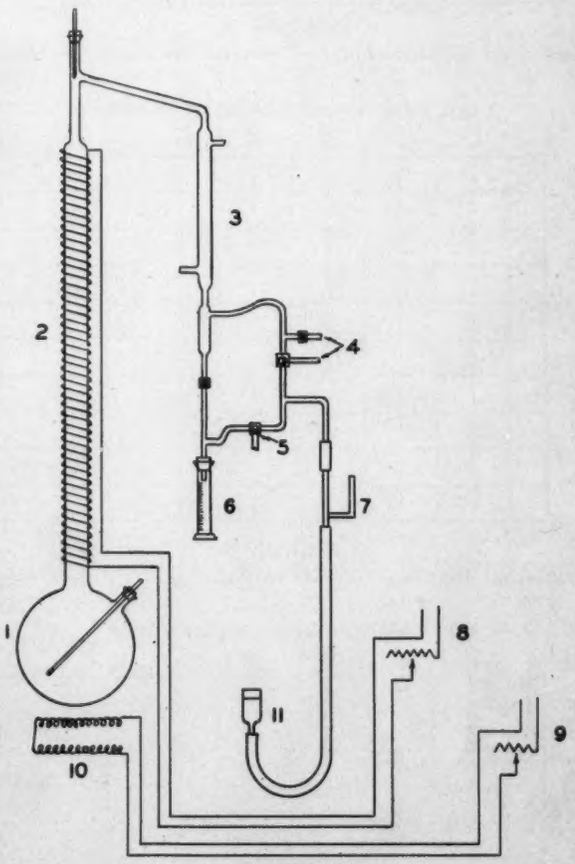


**FIGURE 2**
***True boiling point column for crude oil and theory fractions legend***

1. Distilling flask
2. Packed column
3. Condenser
4. To Hi-Vac pumps
5. Atmospheric vent
6. Receiving graduate
7. McLeod gage
8. Heating circuit for column
9. Heating circuit for flask
10. Heating resistance for flask
11. Mercury container

was practically one for all of the runs, the 45° line was taken as the operating line throughout the length of the column. The number of theoretical plates were obtained by drawing steps between the points, on the 45 degree line, representing the composition of benzene in the distillate and bottoms respectively.

In Figure 9, the results of Figures 5, 6, 7, and 8 are condensed into two curves, one showing the relationship between the number of equivalent theoretical plates and the distillation rate, while the other curve shows the height in inches equivalent to one theoretical plate with respect to the rate of distillation.

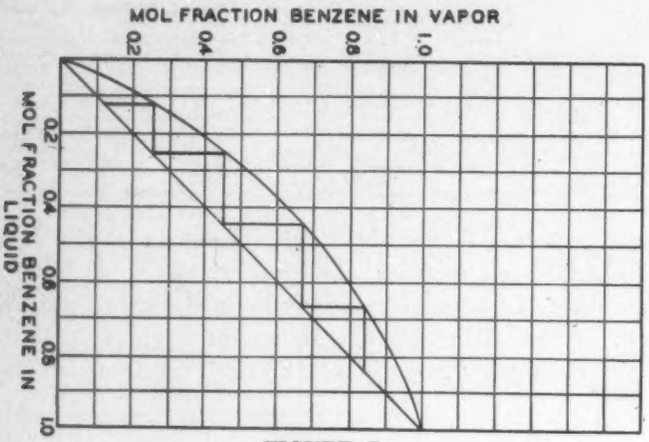


**FIGURE 5**

***Distillation Benzene-Toluene mixture at 1 c.c. per minute***

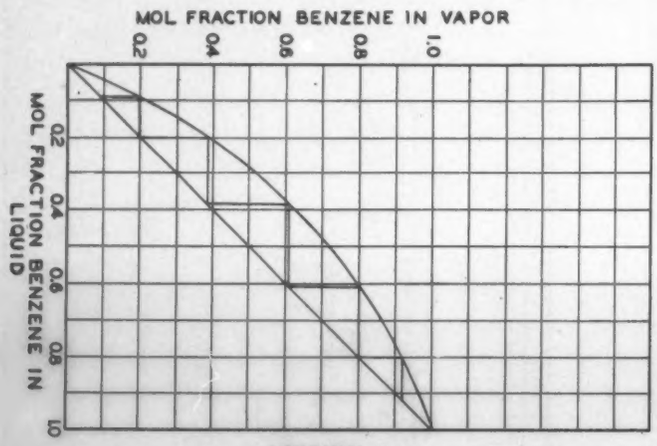


**FIGURE 6**

***Distillation Benzene-Toluene mixture at 2 c.c. per minute***

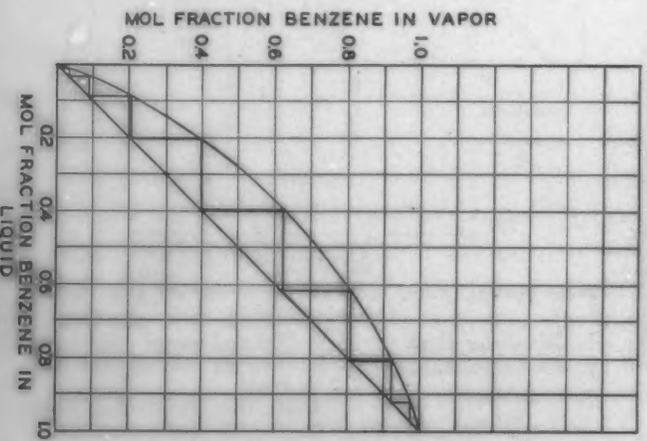


**FIGURE 7**

***Distillation Benzene-Toluene mixture at 3 c.c. per minute***

## CONCLUSIONS

This laboratory study brings out the fact that the time element is an important one in bringing about an approach toward equilibrium conditions between vapor and liquid in a distillation column.

With a knowledge of the fractionating efficiency of a laboratory column, the refinery engineer is in a much better position to analyze the several fractions from a commercial tower, and thereby make calculations involving the efficiency of such plant equipment.

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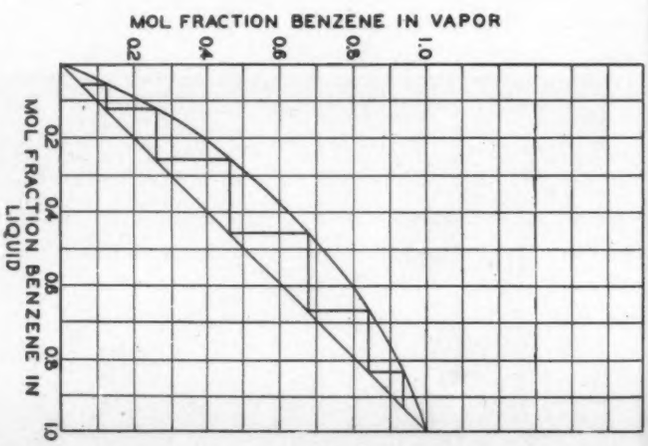



**FIGURE 8**

***Distillation of Benzene-Toluene mixture at 5 c.c. per minute***

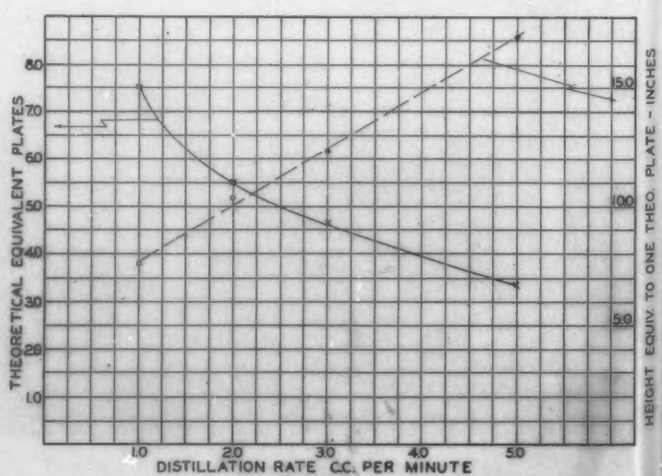



**FIGURE 9**

***Relationship between equivalent theoretical plates and distillation rate. Height equivalent of one theoretical plate versus distillation rate***

# The Salvage of Refinery Wastes

L. C. TRESCOTT

WHEN the recovery of waste material is mentioned there often flashes up in the mind's eye the picture of a junk yard. Just a messy bunch of scrap picked up from anywhere at all. We see the old ragman with his rickety old wagon and his bony horse as he buys the scrap from kids at a half cent a pound. Nothing particularly pleasant in the picture, nothing actually attractive, but—did you ever know of a junkyard that failed to make money?

Mark this as a starter—any value recovered from waste is so much velvet. And keep in mind that efficient methods of waste recovery will pay as large a profit on the money invested as any operation in the refinery.

In this matter of refinery wastes several questions naturally spring up: What are these wastes? Are they worth saving? What, if anything can we do about it all?

The character and quality of waste will vary with the refinery. What will be a waste recovery operation in one plant will be a regular operation in another. Suppose we make a rough splitup by departments.

*Distillation*:

1. Recovery of oil from sewers and separators.
2. Coke from cleaning stills.
3. Waste still gases.

*Acid Treating Operations*:

1. Recovery of acid.
2. Burning of sludge.
3. Fuel oil and asphalt from acid sludge.
4. Black and green acid soaps.
5. Naphthenic soaps.

*Filter Plant Wastes*:

1. Granular clays.
2. Fine clays from contact treating processes.
    1. Solvent reactivation.
    2. Oil recovery.
    3. Use in Portland cement.

*General Waste Materials*:

1. Scrap metals.
2. Scrap timber and wood.
3. Soiled rags, papers, etc.
4. Insulating materials.
5. Pipe fittings, valves, and other equipment which may be repaired and returned to service.

## DISTILLATION DEPARTMENT

The methods of recovery of waste oil from sewers vary with the refinery, its location, and local requirements regarding stream pollution. In every case, however, the sewers empty into some sort of a separator.

A separator is a pond where the oil may be skimmed off the top and the water run to waste. The skimming is generally done by means of a pipe placed at the surface of the oil, but as has been pointed out in a previous article (Refiner, Vol. 13, No. 9, Sept. 1934, p 340), any pool or tank can be skimmed to better advantage by some sort of a weir overflow. Such skimming is continuous and requires no attention.

As was shown in the article cited considerable improvement may be shown in oil recovery by locating small continuous skimmers where they will throw out the particular grade of oil handled in a department before it reaches the large general separators. In many cases this separated oil may be returned to stock or crude instead of being thrown into fuel. In the case of naphthas or light oils these small separators may easily be made gas tight and much evaporation can be prevented. Such separators require little attention and besides the advantages mentioned above go far to reduce the load on the general separators.

In some cases the oil must be recovered from running streams. Due to pipe line leaks, seepage or other reasons it is necessary to pick the oil off the surface of the water. One job of this sort was handled in the following manner: A sort of floating dam was built in sections about 20 feet long. This extended for about a foot beneath the surface of the stream and about as far above. The sections were hinged together with pieces of old belting and the dam was stretched across the current in such a way that the floating oil was held behind it while the water passed underneath. Several swing sections of pipe connected with a suction line on the bank picked up the oil from the surface of the water. A flat boat was operated out in the stream. From this men worked the patches of oil into the suctions, or in some cases it was skimmed by hand into other flat boats. This scheme worked very well. It would

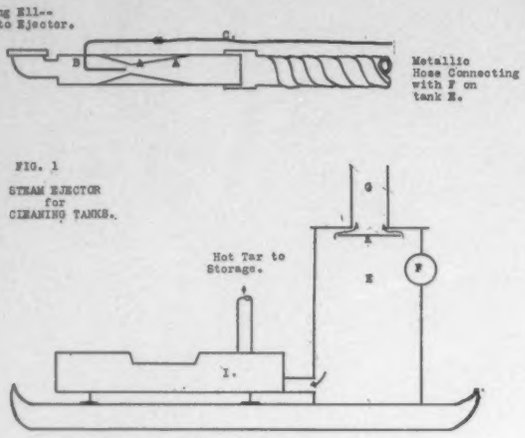



**FIGURE 1**

have been better of course to have prevented the leakage, but this was not possible and it was necessary to get the oil from the surface on account of ships being anchored farther down.

In connection with the salvage of waste oil, particularly of the tarry sludge which often collects in tank bottoms, the following scheme will be of interest. These bottoms are heavy tarry matter such as come from products like pressure still tar and are usually mixed with dirt or fine coke. They are usually located below the coils of the tank and are not in a position where they can be heated or agitated, neither can they be cut with lighter oil and pumped.

Referring to Figure I, A is a steam jet ejector placed on the end of a three-inch metallic hose. B is a high pressure steam jet fed through the metallic steam hose C.

The discharge from the ejector is piped to the discharge tank E. This tank is roughly three feet in diameter by six feet long. The discharge line from the ejector enters tangentially as shown at F, about three quarter way up the tank. The steam separates and escapes through the vent G, which is 12 inches in diameter and is provided with some sort of a baffle K. The tar or oil is pumped continuously from the tank by the pump I. The pump and tank are mounted on a small sledge so that they may be dragged as close as possible to the job.

The ejector with its flexible hose is pushed through the bottom manhole of the tank and moved over its bottom. The steam softens the tars and sediments so that they may be picked up by the jet and sent on their way. The live steam leaves them hot enough to pump easily.

This scheme which is a modification of the ejectors used in cleaning sand filters, etc., does away with drawing or shoveling the tarry sludges out by hand and then having them clog the sewers, or making it necessary to spread them on the ground and bury them. The ejector is pushed over the bottom of the tank and digs its way through the tar and as the ejected material is hot it can, if necessary, be cut with lighter fuel oil and burned.

Coke cleaned from stills may or may not be classed as a waste. Usually it is possible to burn it under stills or boilers or sometimes it may be marketed to advantage outside the plant. The fact seems to be not generally known, but such coke unless very fine, makes an excellent fuel for open fire places, being far superior to the special coals, as cannal coal, etc., generally used for this purpose.

Formerly large quantities of still gases were wasted, but now such gases are usually processed to gain the last bit of liquid material and then burned under the stills. In many cases they may be sold to local gas plants.

## ACID TREATING WASTES

From the acid treating plant we get perhaps the largest quantity of waste coming from any production department. This lies in the acid sludge and in the various milk waters from neutralization with soda.

The values in acid sludge are hard to recover. The situation is more one of disposing of a troublesome waste as cheaply as possible rather than one of getting a profit. Most refineries have some sort of a plant for the recovery of sulphuric acid from sludge. This scheme is too well known to need description here.

The disposal of the tarry sludge after it has been washed for acid is something of a problem. Some sludges mix with fuel oil and can be burned. Others will not, and can only be run out in a low place and buried. Some attempts have been made to use it as a binder for refinery roads but without success.

Asphalts can be made from acid sludge but as a rule they have little value. From the sludges from treating crude oil residuals it is possible to make a very high grade P & V asphalt. This is hard and brittle and has a high gloss. It would seem that there is room for some valuable research along this line.

From some sludges, notably from those from the very heavy acid treats on transformer and white oils it is possible to make soaps which work well as emulsion breakers. Various methods are used in the manufacture of such soaps but here, as in many other practices of the oil business, each sludge is a case by itself. The problem in any case is that of neutralizing the tar acids, usually with soda, and the separation of the resulting soaps. The whole procedure is a matter for experiment, both as to methods of making the soap and to determine the value of the particular soap after it is made. Such soaps will be found to have value in breaking crude oil-water emulsions as well as the emulsions coming from

acid treating operations. In the latter case some caution must be used as the soaps may redissolve in the oil, or in breaking the emulsions may throw back undesirable material.

There have been some attempts in the past to manufacture a crude washing soap from acid tars and sludges. While the results have not been particularly satisfactory, it is a possible field for research. With our present knowledge on the subject, it can be said that the manufacture of soap from acid sludge will only show profit where a cheap emulsion breaker is desired.

Milk waters from the soda neutralization of heavy lubricating oils are usually run to waste but there is some market for sulphonic acid soaps in the tanning of leather. The soaps may be salted from the milk waters. They separate as dark red liquids. The details of their concentration can be worked out to suit each case, and the equipment at hand.

If the manufacture of soaps from sludges and milk waters is to be profitable it will be necessary to develop markets and uses for them. At present the most economical method of handling such wastes is to burn the sludge if possible and to run the milk waters to the separators.

### FILTER PLANT WASTES

In the percolation filter plant the only waste material is the spent filter clay. This has usually been reburned so many times that the value is pretty well taken out of it and it can only be used as fill.

The fine clays from contact treating usually carry a considerable quantity of oil and in any case do not make good fill. The solvent reactivation of such clays will pay and by such means the clays can be used a number of times and any retained oil may be recovered.

The oil may also be cooked from spent clay with hot water. This scheme has been dealt with in a previous article. (Refiner, Vol. 13, No. 2. Feb. 1934. Problems in Handling Filter Cake). The clay mud from such a treatment may be run out as fill and packs very well.

It has also been found that the addition of a small amount of spent contact clay to Portland cement during its manufacture gives an improved smoothness to the resulting concrete and a mixture that is practically waterproof. This process is quite extensively used on the West Coast. While the disposal of the spent clay to the cement plants will not yield any great profit, it will at least bring in enough to cover the cost of disposal of a troublesome waste.

### WASTE CONSTRUCTION AND OTHER MATERIAL

Finally there is the problem of salvaging used construction material, used equipment and other odds and ends in such a way as to recover as high a value as possible.

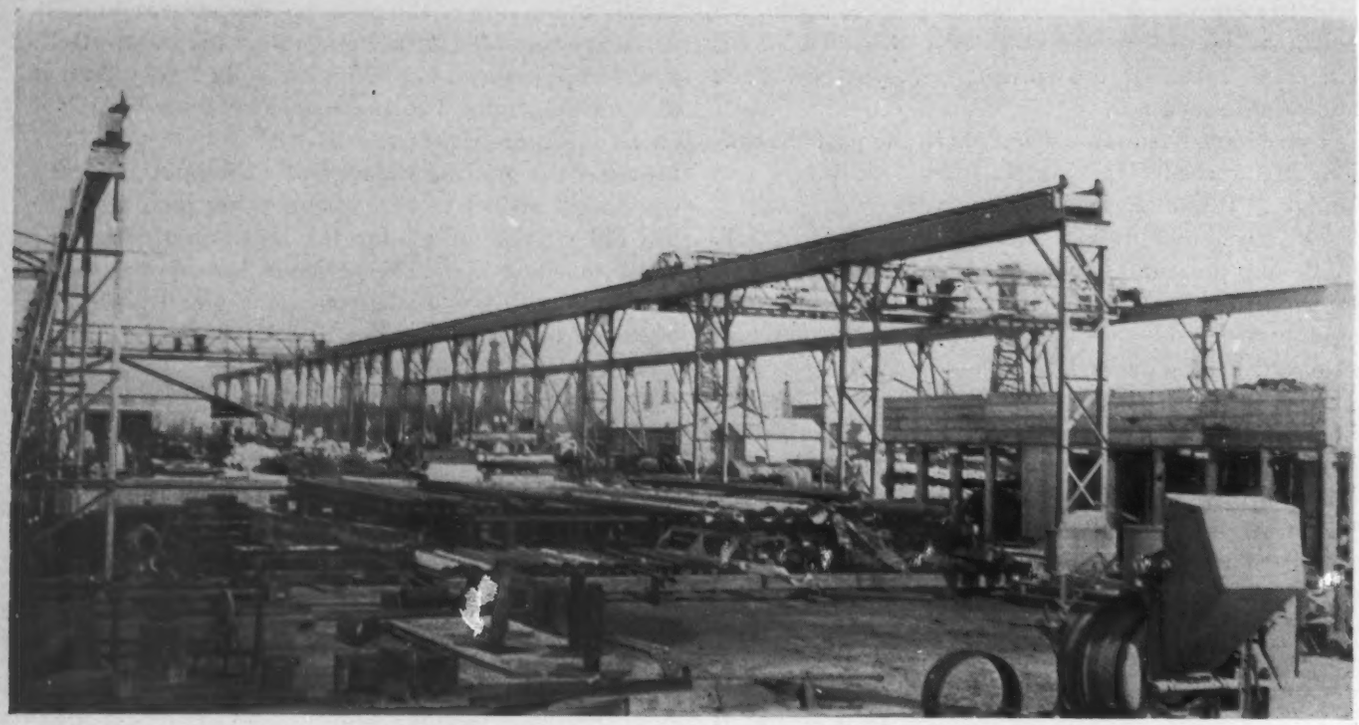
Too many times the salvage department and its yards are regarded little higher than the dump itself. The scrap material is piled a bit more neatly than if it were the dump, but the whole business is looked on as more or less of a nuisance. Where a shop is provided the machines more likely than not are scrap equipment and often the operators are men who are too old or not suited for the work in the regular plant machine shop. Experience has shown, however, that salvage work even on a small scale can be made to pay big profits and it should be organized and rated accordingly.

Naturally the salvage organization will vary with the size of the refinery and with the size and organization of the company operating it. The large concern can support a large department with its head a man experienced in the disposal of scrap materials. It may profitably have its own shops and its own special equipment. In the smaller concerns this cannot always be done, but regardless of the size of the operation the salvage work should be organized. The man in charge of this work may handle it in connection with other duties but he should study his problem carefully. He should keep up on markets and prices of scrap. He should understand the proper grading of scrap in order that the best prices may be obtained. For his knowledge in this line he can well turn to the junk man. The latter knows all the methods of getting the last cent of profit out of scrap material and the salvage man can well profit by his experience.

If necessary the collection of this material may be done as a spare time job by labor gangs from the mechanical department. It is the practice in many plants to designate places in each department where material slated for salvage is placed. From here it is picked up by the salvage gangs.

The construction material thus collected includes not only scrap metal but timber, used lumber and wood scrap. It will pay to use a little care in tearing down scaffolds and forms. The nails should be pulled, the lumber should be sorted and such as is good should be piled in such a way that it can be used again. Large salvage yards have crews who take care of all tearing out and work of such nature. While this is not economical for the smaller plant it is always possible to have a qualified salvage man oversee the work which is done by the regular carpenters.

The salvage yard serves two purposes, it is a storage yard and a classification yard. As it comes in the material should be immediately classified. Much of it will be ready for use without having further work done on it. This should be placed so that it can be easily reached. Scrap material which is to be sold should go at once into its proper bin or pile. These bins or piles should be so located that they may be loaded on trucks or cars. If, as is done in



***Classification and storage yard for salvage material and equipment***

many cases, the scrap is dumped in one large pile to be sorted when the spirit moves certain more or less interested parties, the sorting or classification, if such be done at all, is an expensive proposition. Such a pile is hard to handle and much good material is lost to scrap. It is far better to have the classifying done by a qualified man as soon as it reaches the yard.

Scrap material is often sold direct to the junk man with no attempt at classification. Whether or not it will pay to classify such material depends on several things. Classification as a rule applies largely to size. The large steel plants and foundries of today can handle scrap of any size. The smaller plants with smaller furnaces and cupolas require specification material and pay a premium for it. If the refinery be so located that it can sell direct to the small mills and can make suitable arrangements to do so then it will pay to classify the scrap and to install a shear in the salvage yard that is large enough to cut it up. If the material is sold through junk dealers or to the larger mills then classification will not pay.

It will be well to have the sale of scrap cared for by the purchasing department. Manufacturers from whom they buy supplies often use scrap metals and as an accommodation will take it at such times as the company has it to sell. Junk dealers generally contract to furnish a mill with specified quantities of scrap over a given period. The average refinery cannot do this. It sells the scrap as it is collected, and cannot be certain of any regular supply. For this reason a proper connection between the manufacturers and the purchasing department should be built up.

Methods of classification vary, but the few given below will give some idea as to what such classifications are:

**Cast Iron:**

No. 1—Clean. In sizes that can be handled by one man.

No. 2—As above, but not clean.

No. 3—Light cast iron. Thin sections, etc.

**Steel:**

Boiler clippings and punchings.

Heavy melting steel (cast). From ¼-inch thick —up to 20 inches wide and three feet long.

Specification steel.

As above but up to four feet long.

No. 2—As above but up to five feet long.

6x12 steel.

Up to 12 inches long and up to six inches wide.

Miscellaneous steel.

22 gauge and up. May include wrought iron.

May include pipe up to four feet long.

**Pipe:**

Two inches to six inches. Straight and clean. Six foot lengths or over.

Brass can be profitably classified into red brass and yellow brass. Such a split up brings in more money than if the two are sold together as just brass.

Turnings and borings of different metals should also be kept separate. This can be done easily by

providing portable boxes at the machines, each metal going into its own box. These are later collected by the salvage department.

Thin scrap iron such as can shop trimmings was formerly baled and sold. This material goes into iron of the sashweight grades and for years back has hardly yielded enough profit to pay for bailing. It is best taken direct to the dump.

In the oil refinery the item of valves runs into large figures. By tieing together the purchasing, the engineering and the salvage programs a material saving may be effected in this line. The salvage of valves is complicated by the spreading of purchases and by not sticking to general types. The lines of different manufacturers vary in style and dimensions, and some concerns change designs often enough that it is hard to get repair parts. In specifying valves it would be well if the engineering department were to keep in mind the salvage possibilities of the valve as well as its use in the first place. By holding to as few lines as possible it is easy to hold down the stock of valves it is necessary to carry and by keeping to types that can be repaired easily the useful life of the valves can be at least doubled.

It is interesting to note the cause of most valve leaks. More often than not these are caused by small particles of rust or corrosion which score the valve seats. For this reason it will be found that valve seats of hard brass will give better service than those of the softer yellow brass. Iron bodied valves will have a shorter life, so far as leakage is concerned than those with brass bodies. This is due to a great extent to the hard rust particles which fall down and score the faces.

In some cases it will pay to buy valves with solid brass gates rather than those with brass lined iron gates. In cases of excessive wear the solid gates can be built up at a low cost and refaced. The total cost will be much less than that of a new gate.

In the repair of valves it should be noted that too much grinding of the faces is a frequent source of trouble. Valve faces should be ground just enough to give them a line of contact all around.

Now—as to testing salvaged valves. It must be understood that no valve should be repaired and put back in service unless it is as good as new. There can be no let down on this 100 per cent specification. Anything less is an expensive nuisance if not actually a menace.

In many cases high pressure water test or even a high pressure steam test is required. For refinery purposes this is a mistake. Gasoline is one of the hardest of liquids to hold. Valves that easily hold water, steam or heavier oil will leak with gasoline. On the other hand a valve that will hold air will hold anything. For this reason a test with air should be specified and at a pressure of about 50 pounds per square inch.

But what about valves that are to carry up to 300 pounds, or even as high as 1000 pounds pressure? Of course, on such pressures a new valve would probably be used, but get this—a valve will leak at 50 pounds pressure with air when it will hold at higher pressures with water. In testing with high pressure steam the expansion due to heating will make a valve tight. Testing with 50 pounds of air does take a little more time. High pressure may show a leak at once, but it is not as certain to show all leaks.

A water test may also leave moisture inside the gates. When the valve is put in service some months later there may be a slight corrosion which will cause a leak which was not there at the time the valve was tested. Air leaves the valve dry and it may be sent to the storehouse with the assurance that it will hold regardless of the time it is held in storage.

The shop of the salvage department should have as good machines as those of the regular machine shop and the operators should be skilled mechanics. Too often, because it is an operation for the salvage of junk, junk machines are installed with the result that junk is turned out.

Much of the work of this department consists of cleaning the various items as they come in and seeing that they are properly stored. This should be done carefully and thoroughly by operators who know their work and are on the alert to throw out defective material.

This salvaged material should be stored so that it can be picked out easily for use. The storage yard should cover as much space as it is possible to give it and there should be a covered storehouse for the parts which are to be protected from corrosion. There is little sense in salvaging such material as shafting and then allowing it to rust in the weather.

Under the direction of the salvage department it is often possible to re-size large quantities of obsolete or off-size parts. This can be done either in the salvage shops or in the regular machine shop. The machine shop mechanics handling this salvage repair work should be all-around men instead of specialists. The man who takes care of one class of work is usually not so good when it comes to working with odd jobs and the salvage work, if it is done at all must be done well.

### RAGS, INSULATING MATERIAL, ETC.

During the course of the year hundreds of pounds of clean rags are used in the large refinery. Oil soaked rags are a considerable fire risk if thrown around carelessly. Metal containers should be pro-

vided for them in convenient spots. This is a primary safety axiom in most plants.

New, clean rags at present prices are worth about 8½ cents per pound. Following is a method by which oil soaked rags may be cheaply freed from oil and their absorbent qualities brought back.

The oil-soaked rags are charged into the basket of a tight centrifugal and live steam turned in. After perhaps 30 minutes of this the steam is turned off and the rags whirled dry. This procedure seems to free the rags entirely from oil. From five to seven gallons per 100 pounds charge is recovered. The rags as they come out are dry but stained. For many purposes they cannot take the place of clean rags but for mopping up and rough work they are just as good. The general yield of rags from this washing is 80 to 90 percent so that the saving is appreciable.

Washing with water or naphtha in the centrifugal is not an entire success. Most soiled rags carry a considerable quantity of sand and dirt. With water or naphtha this washes out and gets in the bearings of the machine, requiring frequent tearing down for repairs. With naphtha there are also the losses to be considered. Where the rags are steamed to drive out the oil this sand sticks until they are dumped out on the floor. A few turns of the pile with a fork allows the sand to drop out and leaves the rags ready for use.

Containers should also be provided for waste paper. Under some conditions this may be baled and sold. Usually it will be more economical to burn it.

It is possible to salvage a considerable quantity of torn out insulating material. This is especially true of magnesia and asbestos pipe covering. To some extent it also applies to molded cork covering. Such material which has been torn off in the course of changes or repairs may be ground in a small mill and put in sacks for uses where the insulation is plastered on. The reuse of the ground cork is obvious. New material of this sort cost $3.00 per bag and upward, and the installation of a small mill, together with the use of a little care in tearing out the material and segregating it will soon show a good profit.

Much of the success and profit of a salvage organization will come through the man at the head of it. Considerable vision is required to see the value in waste material and to see its profitable disposal. This man should know his plant processes and their requirements. He should be able to dig up markets and uses for his material, and he should have the backing of the plant organization for his project.

Possibly a regular salvage organization may not seem worth while but this fact should be looked square in the face—waste is loss. Any material returned to service, and scrap sold at a profit, is gain. No plant is so small that it cannot afford to have an eye out for losses. Even though it may be only a part time job, someone should be designated whose duty it is to study this question and then work it out within the facilities of the organization.

# Elements of Stabilization

## PART IV

I. N. BEALL

IN previous articles the writer has indicated and discussed various procedures for the separation of relatively complex light hydrocarbon mixtures into simpler mixtures or into substantially pure components by rectification. Rectification is purely a physical process and the basic principles applicable thereto are those which pertain to fluid flow and energy transfer. Fluid flow in its broader sense includes the flow of either liquids or gases and energy transfer relates to either that supplied mechanically or as heat. The fundamental principles of liquid flow and gas flow are the same and the basic units of heat energy may be expressed in mechanical equivalents.

A fluid system may be energized or de-energized by mechanical means as, for illustration, by compression or expansion. Likewise such a system may be energized or de-energized by the addition or abstraction of heat. The principal means for the utilization of heat energy for the performance of mechanical work is through the medium of an expanding fluid such as, for example, steam.

The resolution of liquid mixtures into fractions of fewer components by continuous rectification depends upon the establishment of various equilibrium conditions between the liquid and vapor phases in which the less volatile components are progressively concentrated and the more volatile components are progressively eliminated. Gases may be cooled by expansion or through the abstraction of heat using a cooling medium. They may be heated by compression or by transfer of energy from a heating medium. For practical reasons the operations incident to rectification require the addition of energy at some points in the system and its abstraction at others. A frequent procedure used for the condensation of gases to liquids is to energize by compression and de-energize by cooling. In the rectifying apparatus proper, heat is added at the "bottom" of the system and abstracted at the "top." All separation by rectification depends upon the establishment of a continuous and progressive series of partial vaporizations and partial condensations whereby the liquid flowing down becomes less volatile and the vapors moving up become more volatile. Briefly summarized, continuous rectification is a process for the separation or concentration of the components of a liquid mixture based upon such repeated and progressive partial vaporizations and such repeated an dprogressive partial condensations as may be effected through the addition and abstraction of energy.

### FLASH VAPORIZATION

Assume that a liquid mixture is pumped continuously through an externally heated coil on which the operating pressure is mechanically maintained in excess of the vapor pressure. The liquid will remain liquid although the energy of the system has been increased. If at some point in the system the pressure is released, partial vaporization will occur and the temperature will drop. This is what happens when a heated liquid mixture passes into the feed plate of a rectifying column, although the liquid may be partially vaporized before entering.

If heated sufficiently the critical temperature of the liquid mixture would be exceeded, under which condition, no amount of pressure could maintain the liquid state. The liquid state simply does not exist at temperatures above the critical. At all pressures below the critical pressure, the vapor in equilibrium with its liquid is known as the **saturated vapor**. An increase of pressure or decrease of temperature will cause a saturated vapor to condense. Superheated vapors will not condense without lowering the temperature to that of the saturated vapor at the corresponding pressure. A mixture may be superheated to such extent that no liquefaction will occur on expansion.

In high pressure rectifiers for natural gas condensates, it is common practice to preheat the feed to the column. This is frequently done without knowledge as to what takes place on the feed plate. It is important to know what the pressure drop is for the feed entering the column if the degree of vaporization is to be calculated. From a practical operating standpoint it would seem that a definite procedure should be adopted, such as, for example, to hold a uniform pressure high enough to insure the full liquid phase up to the point of entry into the column, and then let expansion and vaporization take place within the column. This, too, has its disadvantages as the high velocity of the rapidly expanding vapors would tend to conditions of turbu-

lence within the column. As a matter of plant control, it would appear advantageous to pass the preheated feed first into an exterior vapor liquid separator from which the liquid would flow into the feed plate through a weir meter equipped with look glass and the vapor would pass through a distributor in the free space above the feed plate. Experience gained in the operation of the column would indicate the optimum flow of liquid feed across the weir and would eliminate the guess work as to the degree of vaporization.

## LIQUEFACTION BY EXPANSION

Gases may be liquefied by expansion provided they are previously sufficiently compressed and cooled below a definite temperature which is characteristic for each gas. For each gas there is a temperature at which that gas has the characteristics of a perfect gas, that is, $PV = 1$. Above this temperature, which is known as the Boyle point, the gas will heat on free expansion, below it, the gas will cool. This cooling or heating phenomenon in free expansion is known as the Joule-Thomsen effect and it is one of the principles applied to the liquefaction of the so-called fixed gases, such as air, helium, hydrogen, methane, etc. In free expansion, no external work is done, the cooling is due to internal energy expended in overcoming the cohesive forces acting between the molecules. A gas expanding against external pressure performs work. The energy expended is heat energy, the system cools by reason of the conversion of this heat energy into mechanical energy. There are then three ways by which actual gases may be cooled, namely, (1) by heat transfer to a cooler medium, (2) by free expansion (Joule-Thomsen effect) and (3) by expansion against resistance (work expansion). All three may be used separately or in conjunction to induce liquefaction.

## SPECIFIC HEAT OF SATURATED LIQUID

The specific heat of a saturated liquid increases with the temperature. Specific heat is not a constant and to use it as such is likely to result in serious errors. As a matter of reference, the following data calculated by the writer is given below:

**TABLE I**
**Liquid Methane (Saturated)**

| Temperature Range Degrees F | Specific Heat Water = 1.000 |
|---|---|
| —280 to —260 | 0.820 |
| —260 to —240 | 0.840 |
| —240 to —220 | 0.865 |
| —220 to —200 | 0.900 |
| —200 to —180 | 0.960 |
| —180 to —160 | 1.050 |
| —160 to —140 | 1.225 |
| —140 to —120 | 2.360 |

**TABLE II**
**Liquid Ethane (Saturated)**

| Temperature Range Degrees F | Specific Heat Water = 1.000 |
|---|---|
| —128 to —100 | 0.589 |
| —100 to — 80 | 0.610 |
| —80 to —60 | 0.620 |
| —60 to —40 | 0.640 |
| —40 to —20 | 0.670 |
| —20 to 0 | 0.700 |
| 0 to +20 | 0.755 |
| 20 to 40 | 0.810 |
| 40 to 60 | 0.905 |
| 60 to 80 | 1.075 |

**TABLE III**
**Liquid Propane (Saturated)**

| Temperature Range Degrees F | Specific Heat Water = 1.000 |
|---|---|
| —75 to —60 | 0.533 |
| —60 to —40 | 0.550 |
| —40 to —20 | 0.500 |
| —20 to 0 | 0.525 |
| 0 to 20 | 0.550 |
| 20 to 40 | 0.600 |
| 40 to 60 | 0.600 |
| 60 to 100 | 0.625 |
| 80 to 100 | 0.675 |
| 100 to 125 | 0.640 |

**TABLE IV**
**Liquid Isobutane (Saturated)**

| Temperature Range Degrees F | Specific Heat Water = 1.000 |
|---|---|
| —20 to 0 | 0.450 |
| 0 to 20 | 0.500 |
| 20 to 40 | 0.550 |
| 40 to 60 | 0.600 |
| 60 to 80 | 0.675 |
| 80 to 100 | 0.725 |
| 100 to 120 | 0.800 |
| 120 to 140 | 0.900 |

**TABLE V**
**Liquid Butane (Saturated)**

| Temperature Range Degrees F | Specific Heat Water = 1.000 |
|---|---|
| 1 to 20 | 0.525 |
| 20 to 40 | 0.550 |
| 40 to 60 | 0.575 |
| 60 to 80 | 0.575 |
| 80 to 100 | 0.625 |
| 100 to 120 | 0.650 |
| 120 to 140 | 0.675 |

**TABLE VI**
**Methane**

| Temperature deg. Abs. (°F—460) | Pressure lb/sq. "abs. | Volume Actual cu. ft. | Volume Theo cu. ft. | pv Value |
|---|---|---|---|---|
| 200 | 14.7 | 142.5 | 146.1 | 0.957 |
| 220 | 33.1 | 68.4 | 71.4 | 0.958 |
| 240 | 64.5 | 36.8 | 40.0 | 0.920 |
| 260 | 120.8 | 21.4 | 23.1 | 0.926 |
| 280 | 197.9 | 12.9 | 15.2 | 0.842 |
| 300 | 293.0 | 8.3 | 11.0 | 0.755 |
| 320 | 412.3 | 5.5 | 8.3 | 0.663 |

**TABLE VII**
**Propane**

| Temperature deg. Abs. (°F—460) | Pressure lb/sq. "abs. | Volume Actual cu. ft. | Volume Theo cu. ft. | pv Value |
|---|---|---|---|---|
| 340 | 19.0 | 184.1 | 191.7 | 0.960 |
| 360 | 32.2 | 112.4 | 120.1 | 0.936 |
| 380 | 51.5 | 72.5 | 79.2 | 0.913 |
| 400 | 78.1 | 48.7 | 55.1 | 0.884 |
| 420 | 113.0 | 35.9 | 39.9 | 0.900 |
| 440 | 161.9 | 23.8 | 29.2 | 0.815 |
| 460 | 222.3 | 17.0 | 22.2 | 0.766 |
| 480 | 296.7 | 12.3 | 17.4 | 0.707 |
| 500 | 389.4 | 9.0 | 13.8 | 0.652 |
| 520 | 503.0 | 6.4 | 11.1 | 0.577 |
| 540 | 641.3 | 3.9 | 9.0 | 0.433 |

**TABLE VIII**
**Propane**

| Temperature deg. Abs. (°F—460) | Pressure lb/sq. "abs. | Volume Actual cu. ft. | Volume Theo cu. ft. | pv Value |
|---|---|---|---|---|
| 400 | 9.7 | 436.9 | 442.8 | 0.987 |
| 420 | 16.2 | 269.7 | 278.4 | 0.969 |
| 440 | 25.4 | 176.0 | 186.1 | 0.946 |
| 460 | 38.2 | 119.2 | 129.3 | 0.922 |
| 480 | 55.5 | 83.6 | 92.9 | 0.892 |
| 500 | 77.0 | 60.3 | 69.7 | 0.865 |
| 520 | 107.1 | 44.4 | 52.2 | 0.851 |
| 540 | 142.8 | 33.9 | 40.6 | 0.835 |
| 560 | 186.7 | 26.0 | 32.2 | 0.808 |
| 580 | 239.7 | 20.2 | 26.0 | 0.777 |

**TABLE IX**
**Isobutane**

| Temperature deg. Abs. (°F—460) | Pressure lb/sq. "abs. | Volume Actual cu. ft. | Volume Theo cu. ft. | pv Value |
|---|---|---|---|---|
| 440 | 7.4 | 638.0 | 638.6 | 0.999 |
| 460 | 11.6 | 415.9 | 425.9 | 0.977 |
| 480 | 18.2 | 271.4 | 283.2 | 0.958 |
| 500 | 27.9 | 186.8 | 192.5 | 0.970 |
| 520 | 38.7 | 132.2 | 144.3 | 0.916 |
| 540 | 53.9 | 96.3 | 107.6 | 0.895 |
| 560 | 73.7 | 71.3 | 81.6 | 0.874 |
| 580 | 98.0 | 53.7 | 63.6 | 0.845 |
| 600 | 126.8 | 41.5 | 50.8 | 0.817 |

**TABLE X**
**Butane**

| Temperature deg. Abs. (°F—460) | Pressure lb/sq. "abs. | Volume Actual cu. ft. | Volume Theo cu. ft. | pv Value |
|---|---|---|---|---|
| 460 | 7.2 | 643.8 | 686.2 | 0.940 |
| 480 | 11.6 | 419.3 | 444.4 | 0.944 |
| 500 | 17.7 | 283.0 | 304.5 | 0.932 |
| 520 | 26.3 | 197.2 | 212.3 | 0.928 |
| 540 | 37.6 | 142.7 | 154.2 | 0.932 |
| 560 | 52.2 | 105.0 | 109.0 | 0.963 |
| 580 | 70.8 | 80.0 | 88.0 | 0.908 |
| 600 | 92.6 | 62.1 | 69.6 | 0.892 |

## DEVIATION OF VOLUME SATURATED VAPOR FROM THAT OF A PERFECT GAS

Basis: One mol pound of a perfect gas—359 cu. ft. at 32 degrees F and one atmosphere. For comparison with actual gas (saturated vapor) a mol pound of perfect gas is reduced to the corresponding temperature and pressure.

## SPECIFIC HEAT OF GASES

The specific heats of gases are measured under two conditions, namely, (1) constant volume and (2) constant pressure. The designations are $C_p$ = molar specific heat at constant pressure, $C_v$ = mol specific heat at constant volume, and $c_p$ and $c_v$ are symbols for the specific heats of unit weight (English Units — 1 lb.) of gas at constant pressure and constant volume, respectively. There is some confusion in the use of the designation "specific heat" when no explanation is made as to the condition of measurement. $C_p$ and $C_v$ are both variables, $C_p$ varying as the volume varies with change of temperature and $C_v$ varying as the pressure varies with the change of temperature. Thus the values for both $C_p$ and $C_v$ take the form of curves when plotted against temperatures. In order to recognize the significance of the term "specific heat" the range of temperature, pressure and volume to which the measurements apply must be defined. The rigid thermodynamic relationships are as follows:

**TABLE XI**
**Isopentane**

| Temperature deg. Abs. (°F—460) | Pressure lb/sq. "abs. | Volume Actual cu. ft. | Volume Theo cu. ft. | pv Value |
|---|---|---|---|---|
| 560 | 20.7 | 271.4 | 290.6 | 0.934 |
| 580 | 28.8 | 198.7 | 216.3 | 0.919 |
| 600 | 39.3 | 147.6 | 161.4 | 0.914 |
| 620 | 51.9 | 110.9 | 122.5 | 0.905 |
| 640 | 61.6 | 85.0 | 116.6 | 0.762 |
| 660 | 89.4 | 66.2 | 79.3 | 0.860 |
| 680 | 113.6 | 51.1 | 64.3 | 0.795 |
| 700 | 142.9 | 40.3 | 52.6 | 0.766 |
| 720 | 176.5 | 32.4 | 43.8 | 0.740 |
| 740 | 216.4 | 25.2 | 36.7 | 0.687 |
| 760 | 254.1 | 20.9 | 32.1 | 0.651 |
| 780 | 314.3 | 15.8 | 26.6 | 0.594 |
| 800 | 375.6 | 12.2 | 22.9 | 0.533 |
| 820 | 445.5 | 7.9 | 19.7 | 0.401 |
| 830 | 483.5 | 5.04 | 18.4 | 0.274 |

**TABLE XII**
**Pentane**

| Temperature deg. Abs. (°F—460) | Pressure lb/sq. "abs. | Volume Actual cu. ft. | Volume Theo cu. ft. | pv Value |
|---|---|---|---|---|
| 580 | 22.5 | 262.8 | 276.9 | 0.949 |
| 600 | 31.0 | 192.2 | 207.9 | 0.924 |
| 620 | 42.3 | 141.8 | 157.4 | 0.901 |
| 640 | 54.1 | 108.0 | 127.0 | 0.850 |
| 660 | 67.5 | 82.8 | 105.0 | 0.789 |
| 680 | 94.6 | 64.1 | 77.20 | 0.843 |
| 700 | 119.7 | 50.4 | 62.80 | 0.803 |
| 720 | 149.0 | 39.6 | 51.9 | 0.763 |
| 740 | 184.0 | 31.0 | 43.2 | 0.718 |
| 760 | 224.3 | 24.5 | 36.4 | 0.701 |
| 780 | 262.7 | 19.4 | 31.9 | 0.608 |
| 800 | 326.0 | 15.1 | 26.4 | 0.592 |
| 820 | 387.0 | 11.5 | 22.8 | 0.505 |
| 840 | 457.6 | 6.48 | 19.72 | 0.329 |

(1) $$c_v = \left(\frac{\partial Q}{\partial T}\right)_v = T\left(\frac{\partial S}{\partial T}\right)_v \text{ and } C_v = \left(\frac{\partial U}{\partial T}\right)_v$$

(2) $$C_p = \left(\frac{\partial Q}{\partial T}\right)_p = T\left(\frac{\partial S}{\partial T}\right)_p \text{ and } C_p = \left(\frac{\partial H}{\partial T}\right)_p$$

(3) $$C_p - C_v = \frac{T}{777.6}\left(\frac{\partial V}{\partial T}\right)_p \left(\frac{\partial P}{\partial T}\right)_v$$

(4) $$K = \frac{C_p}{C_v}$$

The total amount of heat necessary to raise a mol of gas from an arbitrary zero point (such as 32 °F.) to some higher temperature is designated as the molal sensible heat content. When the values in Btu per molpound of a gas are plotted against the corresponding temperatures on logarithmic paper the points so determined fall along practically a straight line. It is, therefore, possible to obtain values by extrapolation if several known actual values are available.

## COMPRESSIBILITY

Vapors or superheated gases are either more compressible or less compressible than the so-called perfect gas. For a perfect gas the equation is $PV = P_1 V_1$ or $P_2 V_2$, etc., for every value of P and V. Thus at P - 1 atmosphere, V - 1 cu. ft.

$PV = 1 \times 1 = 1$

$P_1 = 2$ atm. $V_1 = \frac{1}{2}$ cu. ft.

$P_2 = 3$ atm. $V_2 = 1/3$ cu. ft., etc.

so, that in each case PV = 1. This is Boyles Law. Charles Law states that the volume a perfect gas increases directly as the absolute temperature at constant pressure. In other words, a volume of 1 cu. ft. at 400 °F. absolute and 1 atmosphere would occupy 2 cu. ft. at 800 °F. and 1 atmosphere. The conbination of Boyles and Charles Law gives the relation known as the Ideal Gas Law. Actual gases behave as perfect gases only at the Boyle Point, that is, there is a definite temperature characteristic of each gas at which the volume varies in exact inverse ratio with the pressure applied. Above the Boyle Point the values for PV are greater than 1 and below it they are less than 1. The following P-V-T data based upon values from the International Critical Tables illustrates the variation of the pv for Methane.

**METHANE**

| Temperature 0 °C. Vol. cm³/gm | Pressure Atm. | pv | Temperature 50 °C. Pressure Atm. | pv |
|---|---|---|---|---|
| | 1.00 | 1.0000 | | |
| 35.104 | 36.37 | 0.9156 | 44.55 | 1.1216 |
| 30.089 | 41.89 | 0.9040 | 51.55 | 1.1124 |
| 25.074 | 49.21 | 0.8849 | 61.20 | 1.1005 |
| 20.059 | 59.85 | 0.8610 | 75.35 | 1.0840 |
| 15.045 | 76.47 | 0.8251 | 98.34 | 1.0611 |

To compute the actual volume of a gas from a known weight one would proceed as follows:

Methane:

Assumed weight = 40 lbs.

Mol weight = 16.03

Assumed pressure = 117.1 atmospheres

Assumed temperature = 60 degrees F.

Ideal molal volume = 359 cu. ft.

$pv = 0.7715$

Then $\dfrac{359 \times 40 \times 520 \times 0.7715}{117.1 \times 492 \times 16.03} = 6.24$ cu. ft.

Whereas as a perfect gas the volume would have been calculated as 8.11 cu. ft. The actual volume of a gas may be calculated with accuracy by computing the volume as for a perfect gas and then multiplying by the compressibility factor which is the pv value.

## LATENT HEAT OF VAPORIZATION

When sufficient heat is transferred to a liquid the liquid vaporizes. At the boiling point a pure substance will change from liquid to vapor without change of temperature, the amount vaporized being dependent upon the quantity of heat added. The quantity of heat required to convert a unit weight (1 lb. in English units) of a liquid at its boiling point into vapor is known as the latent heat of vaporization. Actually, the heat added has two functions to perform, namely, (1) to overcome the cohesive forces acting between the molecules and (2) to do work of expansion against pressure. The first is known as the internal latent heat and the second as the external latent heat. The internal latent heat is usually very large in comparison with the external latent heat, but it decreases progressively and finally disappears as the temperatures and corresponding vapor pressures approach the critical point. At the critical point it is zero. Thus using saturated steam as illustration:

**TABLE XIII**

| Temp. Deg. F. | V. P. Abs. Lbs./sq. in. | Latent Heat Btu. 1 lb. Total | Internal | External |
|---|---|---|---|---|
| 212 | 14.7 | 970.2 | 897.3 | 72.9 |
| 328 | 100 | 888.2 | 806.7 | 81.5 |
| 382 | 200 | 842.4 | 758.6 | 83.8 |
| 695 | 3000 | 202.5 | 176.0 | 26.5 |
| 706.1 | 3226 | 0 | 0 | 0 |

Dieterici (Ann. der Physik., 25,269, 1908; ibid., 35,220, 1911) has formulated the following empirical equation for calculating the internal latent heat of vaporization. $L. = CRT \log_e \frac{V_2}{V_1}$

Where C is a constant, $V_2$ and $V_1$ are the specific Volumes of the saturated vapor and liquid respectively, R = 1.985 and T = absolute temperature. The calculated values for Isopentane are as follows:

**TABLE XIV**

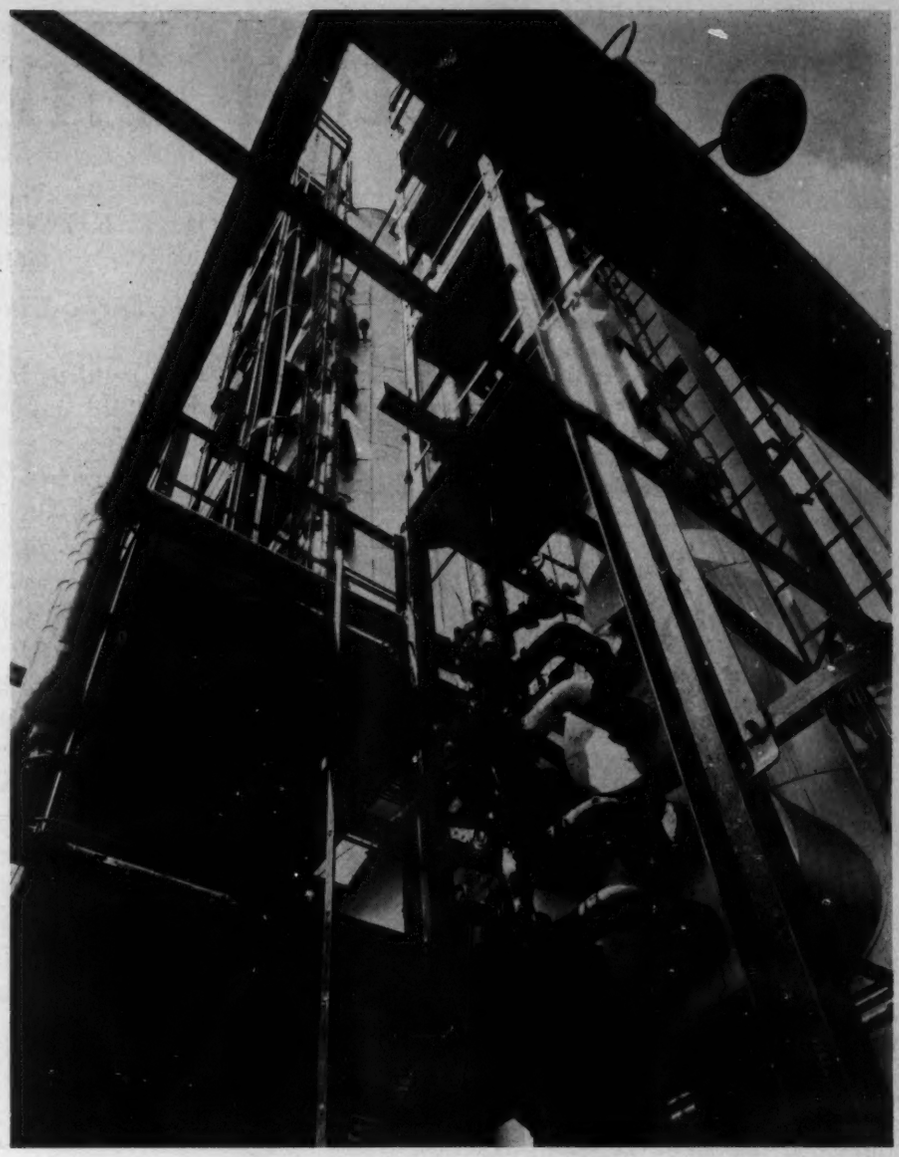
| T. Abs. Deg. F. | V. P. Abs. lb./sq. in. | $v_1$ 1 gm. | $v_2$ 1 gm. | L. Btu. | RT $\log_e \frac{v_2}{v_1}$ | C |
|---|---|---|---|---|---|---|
| 509.4 | 7.56 | 1.5885 | 607.5 | 141.55 | 83.07 | 1.704 |
| 527.4 | 11.08 | 1.6141 | 424.0 | 136.75 | 80.57 | 1.697 |
| 545.4 | 15.78 | 1.6413 | 303.0 | 132.34 | 78.03 | 1.696 |
| 563.4 | 29.66 | 1.7005 | 167.6 | 124.11 | 73.19 | 1.696 |
| 581.4 | 51.4 | 1,7679 | 98.9 | 115.52 | 68.15 | 1.695 |
| 599.4 | 83.2 | 1.8475 | 61.85 | 107.08 | 62.89 | 1.703 |
| 617.4 | 112.7 | 1.9455 | 39.80 | 96.80 | 57.08 | 1.696 |
| 635.4 | 186.8 | 2.0720 | 26.10 | 85.77 | 50.38 | 1.702 |
| 653.4 | 265.7 | 2.2500 | 17.14 | 72.32 | 42.41 | 1.705 |
| 671.4 | 367.3 | 2.5550 | 10.71 | 53.15 | 31.32 | 1.697 |
| 689.4 | 464.0 | 3.1830 | 6.355 | 25.51 | 15.62 | 1.632 |
| 694.4 | 481.2 | 4.266 | 4.266 | 0 | 0 | 0 |

It will be noted that the pv values for the hydrocarbons tabulated decrease with increase of pressure. The frequent and general assumption that the saturated vapors obey the gas laws would therefore

lead to serious errors in design for high pressure rectifiers. However, the volumetric values calculated on the ideal gas laws are consistently higher than the actual values so the column vapor passages are as a rule sufficient. It would, however, make a recalculation of the bubble cap slots spacing advisable to effect more efficient contact. The free space velocity would also be very appreciably influenced.

The pv values would also indicate that the combined cross sectional area of the condenser vapor passages should be diminished over that calculated as necessary on the basis that the saturated vapors obey the ideal gas laws, as vapor velocity is a factor in the computation of the overall coefficient of heat transfer.

It should be noted that as the operating pressure is increased the latent heat of vaporization decreases. It is, therefore, evident that small changes in heat input to the column will affect a greater degree of vaporization than at atmospheric pressure. The density of the vapor and liquid approach each other with increased pressure and at the critical point there is no distinction between between the two. Due to the small difference between vapor and liquid density, the tendency for liquid to "carry over" or "bump" becomes greater.



A knowledge of the P-V-T and related thermodynamic and physical data for the light hydrocarbons would at present be of great theoretical and practical value to the industry. Such data as exists is poorly coordinated and, therefore, difficult to apply. Engineers engaged in design or operation must largely rely upon the use of generalized approximation formulae which not infrequently lead to serious errors or to the use of unwarrantedly large safety factors.

Of the general formulae of application to the prediction of the physical and thermal data for hydrocarbons, that of the law of corresponding states appears as the best guide. This equation, written to conform with the recommendations of the "International Commission" takes the form.

$$\left(\frac{3}{Pr \times V^2r}\right)\left(3Vr - 1\right) = 8\ Tr$$

This is known as the reduced equation of state. In accordance with this equation any two substances, in either the liquid or gas form, when compared at the same fraction of the respective critical temperature, and the respective fraction of the critical pressure have the same volume as expressed in fractions of the critical volume. When at the same fraction of the respective critical pressures, the substances are said to be at corresponding pressures. The terms corresponding temperatures and corresponding volumes have a similar significance. It is thus possible to predict from a known substance and the critical data from an unknown substance what the corresponding state will be. The relationship given by Cope, Lewis and Weber (J. I. E. C. V. 23: 887 (1931) is expressed by the equation:

$$\frac{pv}{RT} = C - zf + \Phi$$

herew $Z = \dfrac{RT}{pcV_1}$, $\Phi$ = a function of $\dfrac{T}{Tc}$ and z, and f = a function of $\dfrac{T}{Tc}$ alone. This equation holds good except in the neighborhood of the critical point.

# Unexpected Emulsions

**A PARALLEL is drawn between refinery treating processes and deliberate emulsion manufacture. Causes of the formation and stabilization of emulsions are given and methods of breaking them are suggested. The subject is handled in an interesting fashion, and to those superintendents, technologists, research workers, engineers, chemists, treaters and others who ever have, and who hope to never have, emulsion troubles, the accompanying discussion is recommended.**

**KENNETH S. VALENTINE and GORDON MacLEAN**

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STRANGELY enough much of the regular procedure in the refinery for the treating of distillates and lubes follows rather closely the best practice for making salable permanent emulsions. How often the refiner misses turning them out, only he can tell, but practically all can recall with a shudder the settling tanks full of cream which finally separarted by an act of providence rather than by any assistance from the technical staff.

Doctor sweetening processes are offenders in this respect, especially where the recirculation method is used in an effort to exhaust the doctor solution. Conditions here are ideal for stabilization and samples of some of the resulting emulsions have been on the shelf in the laboratory for three years without showing any signs of separating into layers of oil and caustic. Some of the pharmaceutical manufacturers would like to know the secret of how to get such stability in their emulsions.

A review of the methods in actual use for making stable emulsions brings out parallels to refinery and oil well practice that show how fine a line divides the smooth flow of gasoline from the business of manufacturing emulsions.

For manufacturing permanent emulsions, one of the big chemical companies, who supplies the materials, recommends one of the following methods:

1. The soap method, which is alternately stirring oil and water into an oil solution of soap.

2. The water method, which is beating oil into a soap solution.

3. The soluble oil method, which is the adding to water of a clear solution of soap in oil.

4. The alkali method, which consists of mixing together water containing alkali and an oil containing an oil-soluble fatty acid.

With slight changes of ingredients all of these have parallels in refinery practice, especially the second, third and fourth. Doctor treating with phenolic impurities present for the second, water washing highly cracked distillates for the third, and caustic treating a distillate containing impurities which unite with caustic for the fourth give an idea of a few such cases. The methods listed are only such ones as fit in with this manufacturer's products. The refineries make millions of gallons of emulsions every day but they are not permanent emulsions.

The bulk of the treating processes depend for their action on the "formation" of emulsions but the smoothness of refinery operations depends on the avoidance of "stabilization". Formation and stabilization are entirely separate actions and possibly, by finding out what differentiates them, a course can be chosen to make the dividing line broad enough to walk on.

### WHAT IS AN EMULSION?

An emulsion is a dispersion of one liquid in another with which it is not miscible; a permanent emulsion is one which does not revert to layers of the original liquids when agitation stops and a temporary emulsion is one which starts to break into separate phases as soon as agitation stops.

This latter type is the refiner's friend for it allows the surface of the treating agent to be tremendously extended, allows this extended surface to be scrubbed time and again with fresh oil and finally sees that the treating agent breaks out so completely that gravity settling is ample.

It takes considerable energy to disperse one liquid in another and apparently some of this energy remains on the surface of the droplets as an attractive force. This then collects all the finely divided materials it can get from the external phase and uses them to construct a protective wall around the drops. The material attracted may be fine particles of almost any substance from proteins to lead sulfide but they must have been suspended in the external phase, probably selectively wet by it.

Take for example three materials, water, extremely fine dry lead sulfide and gasoline. By shaking the lead sulfide with the water a suspension results. When this is smooth the gasoline is added and the

mixture is again shaken. If it acts according to Hoyle the sulfide will transfer itself completely from the water to the oil phase and once there will coat each droplet of water making a permanent emulsion with a limited amount of the water and often with all of it. This is one of the worst the treater has to contend with and every year this one emulsion causes the loss of thousands of barrels of gasoline and other distillates because of the difficulty of breaking it.

An immediate justification for this article would be a simple, easy and inexpensive method of stopping this loss, but unfortunately only centrifuging seems capable of handling the problem.

## CAUSES OF EMULSIONS

1. The primary requirement is that there must be present two liquids which are not completely soluble in each other. There is no way out of this requirement.

2. They must be mixed. This mixing may be voluntary or involuntary, the latter illustrated when a mixture of salt water and oil is released from a pressure well through a valve. An emulsion will almost surely result even though there was no emulsion the moment before. Shear is the force responsible, and the shear from the release of high pressure through a valve is the exact method used by the ice cream manufacturer for breaking up butter fat in milk to form reconstituted cream and ice cream mix. The droplets of fat may be so small that they appear only as a gray background in the field of a 300 X microscope.

3. The passage of one or more substances from one phase to the other. This may result in a stabilized emulsion and very often does, but since it is the basis of all of the treating operations it cannot be laughed off and usually has to be faced with the greatest technical skill that can be mustered to the job. The problem to be solved is how to get the substances out of the oil phase and into the water phase without, at the same time, having a considerable quantity of oil emulsified in the water phase.

The extent of the problem is shown in some vapor phase gasolines, which emulsify as soon as they touch water due to the presence of compounds in solution in the gasoline which greatly prefer the water phase. In this case it is hardly necessary to mix the phases since the emulsion forms spontaneously at the interface. A water wash after sulfuric acid treating is impossible in this case since practically all of the gasoline goes into emulsion. A direct caustic wash with the Beaume gravity of the caustic so regulated as to give the least trouble is the common answer, not only for this gasoline but for many of the other distillates and lubes which show this action.

This explains why refineries running on the same crudes but with different equipment find it necessary to use different strength caustic washes.

These materials, dissolved in the oil, act as dispersing agents, not only causing the formation of emulsions but often making such a fine dispersion that the emulsion is stabilized and rendered permanent.

4. Chemical conditions. This is very similar to the preceding except that, as the material dissolved in the oil contacts the treating agent a chemical change takes place such as the formation of phenolates, napthenates, soaps, etc. The action is very similar to the preceding cause and it ranks among the most favored methods for manufacturing emulsions. Thousands of tons of asphalt emulsions are manufactured yearly by this method, fatty acid being dissolved in the asphalt and caustic soda in the water, the two then being mixed. The formation of soap then completes the job and serves to stabilize the emulsion just enough so that it will break out when it contacts the road surface.

5. Physical Conditions. a. Surface tension. This regulates the drop forming tendency of a liquid, the higher the surface tension of the internal phase, the greater its tendency to form drops. Conversely, the lower the surface tension of the external phase, the lower the resistance to the formation of an emulsion of the second liquid in it. The resultant of these two is called the interfacial tension and is readily measured. Soaps which lower the surface tension of water promote the formation of emulsions of oils in water. Lime soaps which have a corresponding effect on oil promote the formation of water-in-oil-emulsions.

b. Viscosity. This is a prime offender in lubes since it makes dispersion easy by the increased shear developed.

c. Temperature. This is primarily important for its effect on viscosity but also often changes the physical condition of colloids so that they are no longer fine enough to act as stabilizers.

Although these are causes for the formation of emulsions, some of them are also responsible for stabilization as well. There are other factors which cause stabilization and these are serious sources of trouble to the refiner.

## WHAT CAUSES STABLE EMULSIONS?

From the refiner's point of view a stable emulsion is one which does not break out clean in the space allowed for settling. This may be far from a permanent emulsion but it is stable enough to cause interference with production and therefore is serious.

Probably the list should be headed with

1. The presence of emulsifying agents. If we omit dispersing agents from this heading, since they are primarily agents for formation, this classification is narrowed down to colloidally fine materials in the external phase. These build a coating around each

drop, drawn to that position by an almost irresistible force, and by this layer keep the drops from touching each other and so keep them fine enough to stay in suspension.

These materials can be gums, colloidal clays or other impurities in the water supply, tiny wax crystals, carbonaceous materials in still residues, bituminous materials in crudes, soaps in concentrations greater than their solubility, lead sulfide in spent doctor etc., an almost endless list.

The manufacturers of emulsions pay millions every year for such materials while the refiner spends other millions getting rid of them.

Some of them are so positive in their action that they will stabilize relatively coarse dispersions. Some of the layers of emulsion which float between the oil and water layers in the settling tanks show drops a quarter of an inch in diameter but still they do not break out because of the tenacious coating. When cut with a knife in a filter in which the paper has been wet with gas the oil will be released and will run through the paper freely. One such emulsion was found to be 98 per cent of oil held as an emulsion by two per cent of water and enough colloidal matter in the water phase to completely coat the drops.

2. Electric charges on the droplets. Each of the droplets in an emplsion carries an electric charge just as each drop of water in the mist from a waterfall is charged. These charges are all alike and consequently the drops repel each other. This has a serious effect in slowing down settling only when the dispersion is fine. With coarser drops gravity is the stronger force and overcomes the static repulsion. It is a much more serious factor when the specific gravity of the two phases is nearly the same.

3. Extreme fineness of division or dispersion. Here, if the dispersion is fine enough, the peculiar and fascinating Brownian movement can be seen under a microscope and when seen, the reason for the extreme slowness of settling of such emulsions is easily understood. The droplets will be in violent reciprocating motion, never traveling any appreciable distance in a straight line but actually being batted this way and that by other particles entirely invisible. Gravity has practically no effect on such an emulsion. Many commercial emulsions owe their permanence to Brownian movement. Colloid mills and homogenizers often give the dispersion necessary to show this effect.

4. Hydrogen ion concentration. Very little attention is paid to this in refinery practice but in the most carefully prepared commercial emulsions it is carefully controlled. Occasionally a refinery emulsion falls into the favorable range and stabilization results.

5. Specific Gravity. When the specific gravity difference between the two phases is low, trouble is almost unavoidable with gravity settling. Centrifuges can be used to accentuate these small differences and give successful separation. Doctor sweetening sometimes developes trouble from this cause because the lead sulfide is in the oil phase. Drops of caustic are coated with extremely fine lead sulfide particles and so stabilized. These tend to settle out because of their higher specific gravity. At the same time the average specific gravity of the lead sulfide-oil mix is approaching that of the doctor solution and settling is greatly retarded in this range. This is one of the main causes for the troubles experienced with this operation.

6. High Viscosity. The use of gums to increase the viscosity and shear in order to make formation easy and assure stabilization is one of the oldest in the pharmaceutical emulsion manufacturer's bag of tricks. Cod liver oil with malt extract and Scott's Emulsion are illustrations of this. The separation rate is greatly slowed down by viscosity and from the refiner's point of view such emulsions are stable. Fortunately for the oil man the viscosity of petroleum products is very susceptible to temperature so the application of heat is used to lower the viscosity and lessen this source of trouble.

What this list shows is that the treater must contend with practically all of the tricks used by emulsion manufacturers for stabilizing commercial emulsions and still must break these emulsions and turn out a clear product. For weeks things may go along smoothly when suddenly the devil seems to get into the tanks and nothing is right. A few cars of crude from a new well may upset the smoothest running flow and the settling tanks may behave as though they had a high speed mixer helping with the settling. At such a time it may pay to know what to do next.

### HOW CAN EMULSIONS BE BROKEN?

The genius who will invent a panacea for this is still unborn or at least is keeping very quiet so a review of some of the methods which have been used may help. Often the problem becomes simpler when the cause of stabilization is known but usually it boils down to a change of procedure to avoid further trouble and a prayer that the settling tanks will clear up before the available storage space is full.

In general the methods for breaking emulsions are:

1. Heat. This will act to lower the viscosity and give gravity a better opportunity, put some troublesome fine solids into solution, coagulate colloidal materials and cure even more obscure troubles. Now

and then, however, an emulsion appears which needs only a good boil to make it permanent.

2. Shifting the surface tension. Crude oil emulsions are treated by this method very successfully but it takes experts to handle new problems.

3. Very slow agitation or air blowing. This is often called the "chaser" method and is the one most available for most refinery troubles. It is based on the gradual collection of the fine droplets by larger ones which can be easily settled out. Unless the emulsion is permanently stabilized it will be broken by this method. The one requirement is that the agitation must not be so severe as to cause more fine drops. Air, in some cases, especially when combined with gentle agitation, acts to collect the fine droplets on the gas liquid interface where they coalesce and easily settle out.

4. Electric methods although never used in refinery practice are used on crude oil emulsions, especially in California.

5. Selective wetting. An emulsion can usually be broken by running it over excelsior, laths etc., which have previously been wet with oil or water—which ever is the internal phase of the emulsion to be broken. Similar to this action is the common practice of spraying water down through a tower of oil to remove a water phase. The reverse can also be practiced, spraying oil up through a water layer to remove an internal oil phase from the water. The spray in each case must be relatively coarse in order not to form more fine droplets.

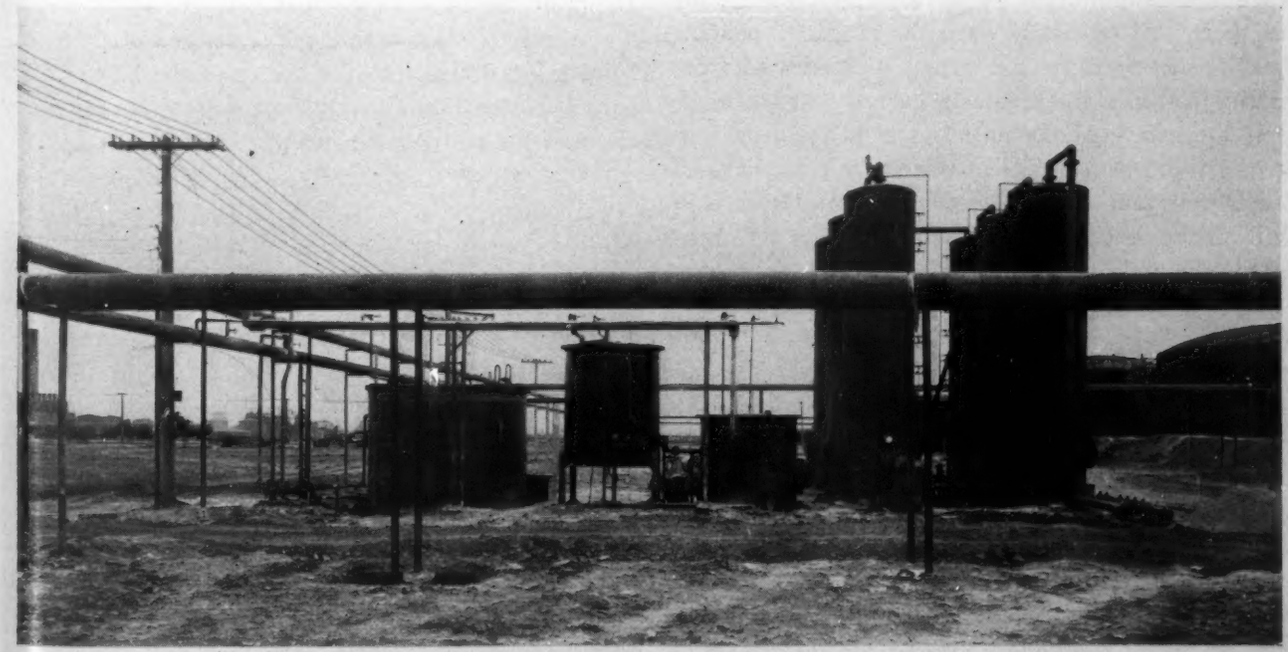
6. The use of small portions of acid or alkali will often shift a stable emulsion to an easily separated one. In those rare cases where the hydrogen ion concentration accidentally becomes favorable for a stable emulsion, a shift one way or the other may cause the emulsion to quickly break out.

7. Chemical change. This may render the colloidal stabilizer soluble, may change it into a form which is wet by the internal instead of the external phase or may make a sufficient change in surface tension to take away the "globular urge" of the internal phase and make it easy to break out into a continuous layer. To use this method an exact knowledge of the stabilizer is necessary and it must be amenable to such treatment.

8. Freezing. This is an excellent method but has doubtful value in the refinery.

This covers the more common methods of forming, stabilizing and breaking emulsions but the one thing to realize is that the best time to break an emulsion is before it is formed. Emulsion forming tendencies can be observed at the installation of a process and a procedure outlined to cure the troubles before they are serious. Work of this sort in anticipation of trouble is much more valuable than high tension work on breaking a few tanks of emulsion which are holding up production.

Once the stable emulsion-forming tendencies of the particular processes and crudes have been noted, an effort should be made to find out what is doing the stabilizing and what can be done to hold these down to a safe level. Do not postpone the laboratory work until after the tanks are full of emulsion and expect an answer in 10 minutes for the chances are you will not get it.



***Plant for continuous chemical treatment of gasoline by sweetening process***

# Ventilation *of the* Pump Pit

GENERAL PETROLEUM Corporation of California operates one of the largest natural gasoline plants in this country, located in the Santa Fe Springs field. The plant is compressor operated, having 64 units housed in five buildings. Two of the compressor rooms contain 14 twin units each, two others house 12 each, and the fifth contains 12. These units are 165 horsepower, making in all a rated horsepower of 10,260. When the field, from which this plant receives its raw material, was at the peak of production, the gasoline manufactured by the plant was in excess of 200,000 gallons daily.

Since proration and other restricting conditions have affected the field in both oil and gas production, the amount of natural gasoline charged to the final fractionator at this time is only about 130,000 gallons daily. Centrifugal pumps that serve the fractionator are placed in a concrete lined excavation near the column, sunk to the level upon which the foundations are placed, to give the steam turbine driven centrifugal pump additional head over the pressure maintained in the supply tank and reflux accumulator so that suction will not be interrupted while handling the high gravity volatile liquids moving to the feed point and top of the column. The pumps are gang; one nearest the turbine taking care of the stabilizer feed, and the other pumping the condensed overhead back to the column for reflux.

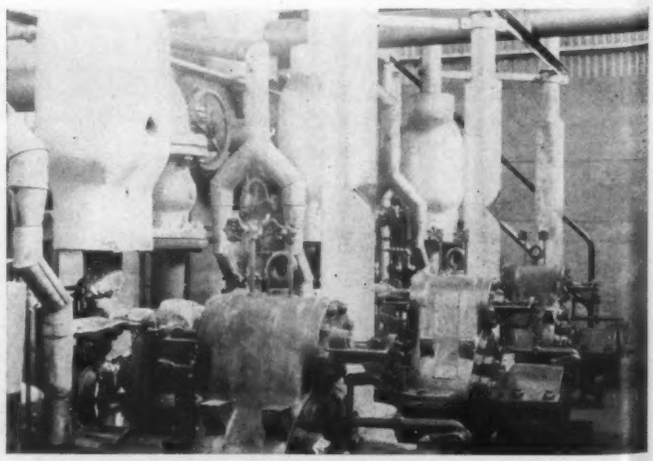
Since packing, both on rotating and reciprocating shafts, operates with more efficiency when not so tight in the gland as to prevent all leaks, the gasoline coming from them, and especially from the propane-isobutane reflux, flashes to vapor the instant it is released from operating pressure and creates a hazard that has to be met if the safety of the men and plant is to be considered. Wind with sufficient velocity to create a draft through the pump room is not a usual occurrence in California, so it became necessary to utilize a forced draft, which picks up the vapors and discharges them to the atmosphere away from any source of possible ignition.

To accomplish this an apparatus was constructed and placed in the pump cellar utilizing a three horsepower explosion proof electric motor and a blower. Both these units are on a concrete foundation on the ground level, the blower being connected to the motor shaft and rotating at the same speed. Suction lines are placed so that each of the four corners of the pit are vented continually, and at the same time, each of the packing glands on all the pumps are cleared of vapors.

The blower is arranged so that one large intake pipe is attached to the suction, and another to the discharge which leads out through the roof of the pump room and extends to a sufficient height that the vapors will be dissipated into the atmosphere and diluted to a point below the explosion point. The suction line has two feeders attached to it, one leading to a single corner of the pump room and extending almost to the concrete floor. The other line runs along the wall of the pit, above the pumps, and serves the other three corners, picking up vapors and air in the same way as the first.

Other lines branch from the main feeder at points above the centrifugal pumps and drop down to a point about three feet from the glands. A Y is placed in these suction lines (all of which are constructed from light sheet metal) so that the glands of both the stabilizer feed pump and the reflux centrifugal are vented. These smaller lines rest on trap supports to prevent vibration or misplacement and almost touch the glands at the stuffing boxes.

This machine is kept in operation at all times, being serviced by the stabilizer operator, and the draft created by the suction is only strong enough to take the air and vapors gently from the pit. All of the suction lines are protected by wire gauze to prevent rags, used by the operators when wiping the units, and other objects from being drawn into the blades of the blower. The only attention the apparatus requires is an occasional oiling of the motor and blower bearings.



***Explosion-proof Motor and Blower***

# Compressor Station Problems

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**This article is abstracted from a paper presented before the Natural Gas Department of the American Gas Association.**

PRIOR to 1926 most natural gas compressor insallations served the dual purpose of gathering and delivering gas. However, in recent years, with the advent of longer transmission lines, we have a situation where natural gas is not only compressed at field stations, but, to facilitate delivery of large volumes through pipe lines in some instances approximating one thousand miles in length, it is recompressed from one to as many as nine times. As a result of this evolution within the natural gas industry the compresssor station has become a factor of greater importance in many gas systems; the selection of equipment requires more careful consideration; location and spacing are factors; design and construction must be carefully executed and all operating details arranged with a view of assuring continuity of operation at a reasonable cost. It is with some of these features that this paper will deal.

## SELECTION OF EQUIPMENT

In the selection of equipment for any given conditions, ideas of engineers differ somewhat, yet installed cost and month to month operating costs, together with reliability of operation, are the real influencing factors and should govern in every instance. Having these objectives in mind, if the problem under consideration is one having to do with an average natural gas pipe line system where there is a wide variation between winter peak and summer minimum load conditions, the following impressions, based upon experiences and observations of the writer, have been found to be generally applicable:

1. In the selection of equipment for small plants, where less than 500 horsepower is contemplated, the use of equipment so designed as to be practically self-contained has been found to be practicable. Employing this type of unit eliminates the necessity for separate auxiliaries and in many instances will permit of some saving in operating labor costs.

2. If the type of plant under consideration is one which will be called upon to meet the condition of widely varying seasonal demands for gas and the power requirement is such that it cannot be met by the installation of a single unit of small size, it is well to give consideration to the value of flexibility by employing two or more smaller units rather than one large one. This will furnish protection against the emergency of enforced shutdowns and more satisfactorily meet the varying demands for gas placed upon the plant.

3. If care is used in the selection of the operating personnel and only trained men of proven ability and reliability are employed, it should only be necessary to provide enough power to meet the peak condition imposed upon the plant. In this connection it may be said that manufacturers' ratings are usually conservative and most gas engines today are capable of carrying an overload for a considerable period of time.

4. In the selection of compressor cylinders for use with equipment known to be conservatively rated, a cylinder diameter may be employed that will result in some overloading of the power end under maximum load conditions, preferably not more than 10 percent of the rated horsepower of the engine. This will permit better balancing of load conditions throughout the year and only require operation of the minimum amount of equipment during periods of light loads.

5. Recent developments in the design of compressors have brought about the advent of plate and feather valves, interchangeable cylinder liners of different diameters, and devices which permit varying the clearance volume. These are of proven value in meeting changing load conditions.

6. To meet today's exacting requirements of service, gas-engine equipment should combine the features of ruggedness, reliability, simplicity of design, and economy in operation.

## DESIGN AND CONSTRUCTION OF COMPRESSOR STATIONS

It has often been said, that there are three principal factors to consider in compressor station design. First of all, provide for plenty of good cooling water; second, correct lubrication; and third, clean air for the power end and clean gas for the compressor end. If these are put into practical effect and care taken of the equipment, long years of good operation will result.

While the ideas of engineers may seem to differ rather materially concerning details of design and construction, it has been the writer's experience that the fundamentals do not differ greatly. Every construction engineer desires to effect an installation that will not only be creditable to him from the standpoint of appearance, but will also function perfectly and continuously under any reasonable condition imposed upon it. These objectives give rise to

the thought of offering some practical suggestions of believed proven value:

1. Factors to be considered in the selection of a plant site include ample space for locating pipe lines and buildings, topographic conditions permitting proper drainage, a subsoil condition capable of withstanding the load to be imposed upon it and recognition of the fact that an adequate water supply is important.

2. All concrete materials used in foundation work should be clean and of good quality.

3. All large engine foundations should carry steel reinforcing.

4. In locating buildings and other facilities consideration should be given to the convenience of the personnel; the elimination so far as possible of all fire hazards and such provision for expansion as may be deemed advisable.

5. In large plants main building foundation design providing for a full basement offers advantages that seem to justify the small additional cost entailed.

6. The design of buildings incorporating adequate lighting and ventilating features makes for improved working conditions.

7. A hand operated crane installed in the main building for the purpose of facilitating repairs generally proves to be a good investment.

8. The installation of valves in the suction and discharge lines at or near the property lines or at some considerable distance from the plant buildings for use in an emergency is recommended.

9. In the construction of large diameter gas headers avoid placing them in too close proximity to the main compresssor buildings and employ small diameter pipe for compressor suction and discharge lines, making ample provision in the latter case for expansion and contraction.

10. The elimination of all joints of any kind or character in high-pressure gas lines located under the floor level of the compressor room has proved to be good practice.

11. Even in rather isolated locations consideration may well be given to the elimination of dwellings for employees with the possible exception of one for the plant superintendent. The same applies to machine shop equipment and any other extras not actually required to meet the function that the plant is intended for. In short, build well but not too well; provide only those facilities necessary for the satisfactory operation of the plant and the result will be a lowered first cost and, undoubtedly, some later saving in operation and maintenance cost.

## OPERATION AND MAINTENANCE

There are many problems incident to the proper operation and maintenance of a compressor station, regardless of its type, size, location or other physical features, but, without doubt, the one of principal importance is the selection of men. This applies particularly to the superintendent in charge and the engineers directing each shift. Proper qualifications should not only take into consideration a man's experience and past record as well as his intelligence and willingness to work, but should include the attributes of honesty and reliability, coupled with the ability to think clearly and act in an emergency. Confused thinking on the part of employees has no place in the operation of a compressor station. Instances have been known where well designed and constructed plants containing the best equipment to be had, were, through carelessness and inefficiency on the part of the operators, allowed to get in such a condition within a period of four of five years that continuous operation of the equipment was impossible, maintenance costs were excessive and the resulting service most unsatisfactory.

A water supply of good quality and ample quantity is always a necessary adjunct to the operation of any power plant. This often becomes a matter of consequence with the average type of compressor station installation for the reason that the selection of a site is often influenced by line flow rather than proximity to a suitable water supply. As a result many installations are dependent upon wells, others upon running streams, and still others upon impounded water for plant purposes.

Each source of water supply offers problems of some sort. A well supply is, in many areas, difficult to find in sufficient quantity to meet all requirements, and, when present in an ample amount, usually has the disadvantage of excessive hardness with resulting scale forming qualities, unless water outlet temperatures are kept very low, which, of course, has the effect of lowered thermal efficiency of the prime mover. The lifting of well water from deep strata not only requires a power outlay, but involves the maintenance of pumping equipment. An interesting installation, which tends to overcome the mechanical difficulties encountered with the average deep well pumping equipment, utilizes gas lift. Gas to flow the well is taken from a line at sufficient pressure to start and continue the flow of water from the well. The commingled gas and water are discharged into a large closed separator, which is operated under a pressure of several ounces; the water is trapped off and the gas, after separation from the water, is discharged into the low-pressure fuel line leading to the main engines.

Water from a flowing stream where the flow is constant and of sufficient quantity to meet the needs of the plant is often preferred to any other source of supply. This, however, has its drawbacks and invariably in addition to providing the required lines and pumping equipment entails an additional expenditure for strainers or preferably a settling basin for the removal of debris and silt.

Evaporation losses, seepage and the quantity of

water required for plant use are variables and the extreme or maximum condition should receive consideration if it is necessary to impound water. In this connection a record of evaporation losses experienced during the summer months of 1934 at a plant near Louisburg, Kansas, is presented in the following tabulation and is offered for such value as it may have in guiding those who are compelled to resort to the use of impounded water.

| | May | June | July | August |
|---|---|---|---|---|
| *Mean atmospheric temperature | 71.0° | 83.2° | 88.4° | 84.6° |
| *Mean humidity | 50% | 48% | 38% | 47% |
| Mean water temperature | 72° | 83° | 86° | 85° |
| Total monthly evaporation loss | 7.44" | 10.68" | 11.81" | 11.19" |
| Average daily | .24" | .356" | .381" | .361" |

*From Kansas City, Missouri, United States Government Weather Bureau reports.

A practice employed by many engineers in the installation of circulating water pumps, where a centrifugal type is used, is to locate the pump so that the suction line will be flooded and thereby avoid the difficulties usually encountered where water has to be lifted some distance. This minimizes required attention to water pumps, and gives better assurance of a continuous supply of water for cooling purposes.

The use of a single grade of lubricating oil generally will suffice for small plants. This needs to have enough body to provide satisfactory cylinder lubrication and still have a sufficiently low-cold test to permit of free flowing for bearing lubrication in cold weather. A large plant will justify the use of two grades of lubricating oil, one for power-cylinder lubrication and the other for general purposes. There are many oils offered to the trade, and, while climatic or other conditions may sometimes govern their selection, the two oils of the following specifications have been found to meet satisfactorily all reasonable requirements of both single and double acting gas engines.

| | Gravity | Max. % Carbon | Flash Min. | Fire Min. | Vis. @ 100 | Vis. @ 210 | Pour Point | NPA Color (Max.) |
|---|---|---|---|---|---|---|---|---|
| Cylinder lubricating oil | 23.5 | 1.40 | 480 | 535 | 1800 | 100-115 | 0-10 | 7½ |
| Bearing lubricating oil | 26.0 | .45 | 415 | 475 | 380-400 | 55 | 0-10 | 5½ |

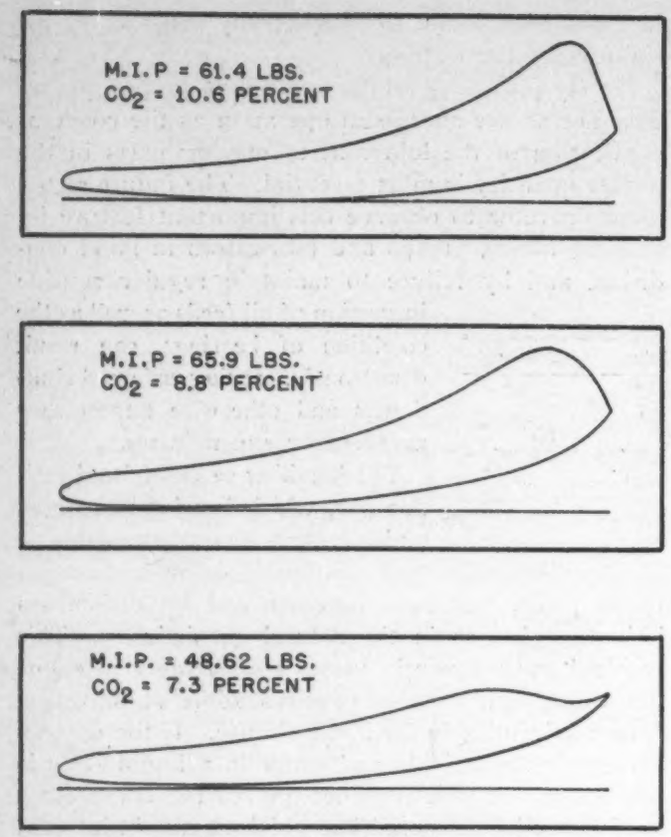
In the average compressor station, where single- or twin-tandem, double-acting engines are employed and two grades of lubricants are used, it will be found that the cylinder oil dropping from the rods commingles with the lighter oil and after a time the latter tends to become heavy and unfit for use. As a means of overcoming this condition, particularly during winter periods and for the further purpose of gradually replenishing the filter stock with new oil, a plan is often followed whereby compressor-cylinder lubrication is supplied by oil taken directly from the filter. This practice permits adding new oil to the filter system from time to time and this mixture has been found to be generally satisfactory for compressor lubrication.

Merely providing lubricating oils of proper quality does not assure successful operation as the constant application of the lubricant to moving parts in the proper quantity is most essential. The failure of the plant operator to observe this important feature by keeping filters, pumps and lubricators in good condition, and by failure to maintain regular routine inspection of oil feeds as well as the condition of bearings, can result disastrously, causing enforced shutdowns and otherwise unnecessary maintenance expenditures.

The handling of casinghead residue gas, which has been gathered under vacuum, before extraction of the gasoline and a small amount of air infiltration has taken place, has been accompanied by difficulties hitherto unknown in the natural gas industry. This residual gas frequently varies considerably in calorific value, and usually requires some stabilization before it is suitable for domestic use. If the oxygen content is appreciable and water in a liquid state is present in the pipe lines leading to the compressor station, we have a condition which results in internal corrosion and the finely divided iron oxide thus formed has been the source of a lot of annoyance, causing valve leakage, making lubrication ineffective, often resulting in breakage, and invariably causing lowered volumetric efficiency. Either the elimination of the water in the pipe line or the oxygen in the gas will relieve this trouble. The former is accomplished by dehydration through the use of refrigeration. However, the removal of oxygen becomes a complicated and expensive process involving partial oxidation.

Where dust is present in a pipe line, whether it originates from this or other sources, it appears that the best means of protecting plant equipment can be provided by the installation of a dust separator.

Leakage—that ever present bugaboo in the operation of every gas property—should not be overlooked at compressor stations. Because of the multiplicity of valves, connections, stuffing boxes, et cetera, required in every installation, stations become a fertile source for this sort of thing. Within the last few years through the efforts of the United States Bureau of Mines a standard method of determining leakage rates in pipe lines has been devised. Many operating companies have adopted this method and surprising results have been obtained in the way of accomplishing reduced gas leakage. This applies particularly to new construction and it is now considered a poor result, if, following completion, a test does not reflect an actual leakage rate of considerably less than 50 M cubic feet per year per mile




***Gas Engine Indicator Cards, showing the variation of power developed from a fixed quanaity of fuel gas and various air-gas mixtures—air varied to obtain various percentages of $CO_2$ in exhaust.***

of three-inch pipe at 100 pounds pressure per square inch. This practical method should occasionally be applied to compressor station piping, as doubtless the results in many instances would be astounding.

In the Mid-Continent, as well as some other sections of the country, the dust problem is by no means confined to the gas flowing through the lines. In a large area extending from the Dakotas to western Texas dust storms of increasing severity and frequency have become a major problem in the operation of compressor stations.

If a compressor station is located in an area subjected to these visitations, three separate problems are presented: (a) cleaning of the air entering the power cylinders, (b) the prevention of a sand deposit in and upon bearings or other wearing parts, and (c) its elimination from the interior of the buildings in the interest of cleanliness. This situation, as it applies to western Kansas, parts of Oklahoma, and the Texas Panhandle, is a serious one and, if means of successfully combating the effects of these sand storms are not found, the result will be increased expenditures for maintenance and possible difficulty in maintaining service. Some form of filter, mechanically driven or stationary, installed on the free air intake to power cylinders, will give assurance of clean air. The second problem seems more difficult to solve. In one instance screen over a supporting frame work has been placed over cross head guides. These improvised housings are covered with canvas during the storm periods. This proves reasonably effective but has the disadvantage of complicating routine inspection, if the equipment must be in service during the period the storm prevails. So far as known to the writer no satisfactory solution of the third problem has been found and the whole subject matter is presented with the hope of inviting discussion leading to helpful suggestions.

Mention may well be made of the value which should result from the regular use of an engine indicator as a guide to engine performance and an aid in securing greatest economy in the operation of a compressor station. Gas engines are very sensitive to variations in mixture conditions and, since the indicator provides a graphic picture of what takes place in a power or compressor cylinder, its use by an experienced operator affords the means of effecting economies. The results of several carbon dioxide determinations, made from exhaust gas samples taken coincident with indicator cards, are presented for the purpose of showing the sensitivity of a gas engine power cylinder to mixture variations and the power loss resulting from an improper mixture. It is of interest to note that, with the load condition reflected by these cards, the exhaust gas analyses indicate the optimum percentage of $CO_2$ to be approximately nine percent.

In conclusion I wish to reemphasize the belief that the type of man on the job, from superintendent to oiler, has more to do with the solving of problems and the resultant successful operation of a compressor station than any other one thing. If he is the right kind of person, the little things about the plant will receive attention before they become big things involving expensive replacement; a neat, clean, and orderly existence will be made effective applying to the condition of the buildings, grounds and equipment alike; good housekeeping will prove profitable and the entire plant personnel will be content and happy in its work, even though the plant may be far removed from a center of population.

(*Continued from Page 2.*)

Trusty . . . A ruling dignitary in Siam wished colored asphalt paving material, so Casmite Oil Company in California prepared the red and the green products for paving the garden walks at the potentate's summer home, and the operation and design of this asphalt producing plant will be described . . . And there will be more.

And the March issue is going to be a nice surprise, and it is promised right now that it will prove to be an issue of *The Refiner* which will be much read, much used, and carefully preserved for future reference.

## Standard to Appeal Cracking Patent Litigation Decision

ON December 11, 1934, Federal Judge John P. Barnes handed down at Chicago the decision that Globe Oil & Refining Company did not infringe two patents of Standard Oil Company (Indiana), and further, that these patents were invalid in view of the prior art.

The patents in suit were the Lewis and Cooke patent which covered the use of a "bubble tower" directly connected to the cracking unit, and the Shaeffer and Brown patent which covered generally the cracking apparatus used by Globe Oil & Refining Company at its Lamont, Illinois, refinery. The suit was tried before Judge Barnes in the spring of 1934.

Standard Oil Company (Indiana) conducted the first commercial oil cracking operation at its Whiting, Indiana, refinery in 1912-1913 and has a large number of patents covering cracking processes. Through the course of the years practically all of the oil companies operating cracking processes have purchased licenses under Standard's patents, which include not only the patents held invalid by Judge Barnes but numerous other patents. However, certain refiners of recent years have purchased from Winkler-Koch Engineering Company and have operated cracking units without purchasing licenses; and the Globe unit in question was one of that group.

Judge Barnes adopted the findings of fact and conclusions of law submitted by the defendant in toto. It is certain that Standard Oil Company will appeal.

In passing, it may be remarked that Universal Oil Products Company of Chicago and New York recently sustained one of its patents against a cracking unit of the same type operated by the Root Refining Company, and this case is now also on appeal. A case involving a charge of infringement of patents held by Gasoline Products Company of New York by a refinery employing the same general type of cracking process was recently tried at Santa Fe, New Mexico, before Judge Bratton, former United States senator from New Mexico. No decision has yet been handed down in this case.

## The Look Box

## Crude Production Allowable Increased

AN increase in the national daily allowable crude oil production, effective as of Monday, December 17, for the balance of December and for the month of January was announced December 18 by Oil Administrator Harold L. Ickes. The increase aggregated 153,300 barrels and was spread among the producing states. The total for the balance of December and for January was placed at 2,460,300 barrels daily, as compared with 2,307,000 for the first 16 days of December.

Technical experts of the Bureau of Mines recommended the increase to the administrator so that sufficient gasoline could be made to bring gasoline inventories up to the necessary economic levels for the next few weeks. In addition, they recommended that the amount of crude necessary be taken from daily production, instead of from storage.

The largest increase was to Texas, which received a raise of 65,500 barrels from 941,300. Oklahoma was second with an increase of 37,700 barrels from 451,600, and California was third, with an increase of 17,100 barrels from 456,800. The distribution among the other states: Kansas, increased 13,200 from 123,900; Louisiana, increased 5700 from 94,000; Colorado, raised 500 from 3000; Montana, raised 1300 from 8000; New Mexico, raised 3900 from 45,900; Wyoming, increased 3100 from 32,600; Arkansas, increased 2000 from 29,000; Michigan, up 200 from 27,900; Pennsylvania, up 500 from 35,000; Ohio, up 200 from 11,500; Kentucky, up 2300 from 11,700; Indiana, up 100 from 2100. Illinois, New York and West Virginia remained unchanged at 11,700; 10,000 and 11,000, respectively.

### Conventions

**S. A. E.** Society of Automotive Engineers, will hold its annual meeting at the Book Cadillac Hotel, Detroit, January 14 to 18.

**A. I. M. E.** American Institute of Mining and Metallurgical Engineers, Petroleum Division, will hold its annual meeting in the Engineering Building, 29 West 39th Street, New York, on February 18, 19, 20 and 21.

**I. M. I. S.** On the last day, February 21 of the A. I. M. E. meeting will be a joint symposium on the use of metals in the petroleum industry held in conjunction with the Institute of Metals, Iron and Steel.

**A. C. S.** Beginning April 22, American Chemical Society will hold its semi-annual meeting in New York City.

**N. G. A.** May 1, 2, 3, Natural Gasoline Association of America will hold its annual meeting at the Tulsa Hotel, Tulsa, Oklahoma.

**A. I. C. E.** Early in May American Institute of Chemical Engineers will meet for its semi-annual convention in Wilmington, Delaware.

**A. P. I.** American Petroleum Institute will hold its fifth mid-year meeting in the Mayo Hotel, in Tulsa, May 14, 15, 16.

**P. G. C. O. A.** Pennsylvania Grade Crude Oil Association plans to hold its annual convention at State College, Pennsylvania, June 20 and 21.

**A. S. T. M.** American Society for Testing Materials annual meeting is scheduled for June 24 to 28 at the Book Cadillac Hotel, Detroit, Michigan.

## Gasoline Quota For January

THE allowed production of gasoline by refinery districts (including the production of straight run and cracked gasoline and the natural gasoline blended therewith either at refineries or terminals) has been determined, in accordance with Section 3, Article IV of the Code, to be, for the month of January, 1935, as follows:

| District | Amount (42 Gal. Bbls.) |
|---|---|
| 1. East Coast | 5,510,000 |
| 2. Appalachian | 1,517,000 |
| 3. Indiana-Illinois-Kentucky | 5,453,000 |
| 4. Oklahoma-Kansas-Missouri | 4,977,000 |
| 5. Texas: | |
| (a) Inland Texas | 2,266,000 |
| (b) Texas Gulf Coast | 6,963,000 |
| (c) East Texas | 468,000 |
| 6. Louisiana-Arkansas | |
| (a) Louisiana Gulf Coast (including Alabama) | 1,264,000 |
| (b) North Louisiana-Arkansas (including Mississippi) | 708,000 |
| 7. Rocky Mountain | 750,000 |
| 8. California | 4,874,000 |
| Total United States | 34,750,000 |

## A.S.T.M. Tentative Standards

THIS publication issued each year by the American Society for Testing Materials is the only volume containing all of the A.S.T.M. tentative specifications, methods of test and definitions of terms

covering engineering materials and the allied testing field. These tentative standards, issued as proposed standards, embodying the latest thoughts and practices, find important applications throughout industry.

The 1934 edition of the Book (1250 pp.) contains 236 tentative standards. Of these 48 are included for the first time, while some 60 were revised this year and are given in their latest approved form. A general classification of the items, with the number in each group follows:

| | |
|---|---|
| Ferrous metals | 25 |
| Non-ferrous metals | 25 |
| Cementitious, ceramic, concrete and masonry materials | 48 |
| Paints, varnishes, lacquers and paint materials; waterproofing and roofing materials | 30 |
| Petroleum products and lubricants | 13 |
| Road materials | 31 |
| Rubber products; textile materials; electrical insulating materials | 42 |
| Miscellaneous materials and general methods | 22 |

### New Tentative Standards

New tentative specifications published for the first time in 1934 cover the following ferrous and non-ferrous materials: Electric-fusion-welded steel pipe for high-temperature and high-pressure service; alloy-steel castings for valves, flanges and fittings for service at temperatures from 750 to 1100° F., and for the same temperature range, seamless alloy-steel pipe; sheet-copper silicon alloy; copper-silicon alloy rods, bars and shapes, and plates and sheets; also, magnesium-base alloy ingot for remelting, and magnesium-base alloy die castings.

In the cementitious, ceramic and masonry field new standards cover portland cement mortars (compressive strength test), sodium silicate for curing concrete, ground fire clay, refractories for the construction of incinerators and structural clay tile (sampling and testing.)

Other specifications which have been included for the first time cover such important materials as fuel oils; various types of emulsified asphalts; woolen and worsted yarns; titanium barium pigment; titanium calcium pigment; zinc sulfide and high-zinc sulfide lithopone; insulated wire and cable (class A, 30 percent Hevea rubber compound); vulcanized rubber (test for compression set); rubber compounds (test for abrasion resistance; creosote and creosote coal-tar solution.

### Revised Tentative Standards

Extensive revisions have been incorporated in the requirements for cold-rolled strip steel; black and hot-dipped zinc-coated welded and seamless steel pipe for ordinary uses; reinforced and non-reinforced concrete sewer pipe; timber piles; friction tape for general electrical use; and grease wool and allied fibers.

In addition to the 236 A.S.T.M. tentative standards, the 1934 Book of Tentative Standards includes all proposed revisions of standards, which are published to elicit criticism before final adoption. Changes in 60 standards have been proposed.

To facilitate the use of the book a complete subject index has been included, listing items under the materials and subjects to which they apply; and two tables of contents are given, one listing the standards in the order they appear grouped under general subjects) and the second listing the items in numeric sequence of serial designations.

Copies in cloth binding at $8.00 each, or in heavy paper cover, $7.00, can be obtained from A.S.T.M. Headquarters, 260 S. Broad Street, Philadelphia, Pa.

## Use of Metals in The Petroleum Industry

INTERESTED engineers and technologists have been invited to attend a joint symposium on "The Use of Metals in the Petroleum Industry" to be held January 21, by the Institute of Metals, Iron and Steel and the petroleum division of the American Institute of Mining and Metallurgical Engineers. Sessions will convene in the Engineering Societies Building at 29 West 39th Street, New York on the last day of the A.I.M.E annual meeting, which is scheduled for February 18 to 21. Papers on the following subjects will be presented: heat resisting alloys, heat interchangers and condensers, refinery pumps, sucker rods, and developments in pipe and tube products.

## Natural Gasoline Plants In the United States

THE Bureau of Mines is distributing Information Circular 6808, "Natural Gasoline Plants in the United States, January 1, 1934," which is available from the Section of Publications of the Bureau at Washington, D. C. The circular reviews briefly the history of gasoline plant construction and operation activity during recent years. The list includes all plants reporting to the Bureau arranged by state in alphabetic sequence. There is reported a total of 741 operating plants with 128 shut down, making a total of 869 plants in this country. The total capacity is given as 10,860,000 gallons daily, of which 9,181,000 gallons capacity is operating and 879,000 gallons capacity shut down. The listings include name of company, status, location, daily capacity in gallons and type of plant installed.

## Report on the Use of Tin Compounds in Lubricants

A VALUABLE property of tin compounds is described by Dr. E. W. L. Mardles in a publication recently issued by the Internation Tin Research and Development Council. The deterioration of oils used for engine lubrication is due mainly to oxidation, which causes the formation of sludge, and is accelerated by copper, iron, and certain other metals. Tin and its compounds, on the other hand, are reported to be effective in inhibiting sludge formation. In the publication, "The Beneficial Use of Tin Compounds in Lubricants," a series of graphs show how the addition of such compounds as tin oleate or tin tetraphenyl to the oil reduces the amount of oxidation and the viscosity rise on prolonged heating. The publication is presented through permission of the Air Ministry of Great Britain. Copies of this booklet may be obtained by writing L. J. Travener, U. S. Tin Research and Development Committee, 149 Broadway, New York, N. Y.

## South Louisiana Crude Analyzed in Bureau Report

FOR several years the Bureau of Mines has been conducting an investigation of crude petroleum from producing fields in the United States and the western hemisphere and has published a series of valuable reports on these fields. The most recent covers the 14 fields in 10 parishes in the Louisiana Gulf Coast area and analyses of these crudes are incorporated in Bulletin R. I. 3253, available gratis from the Section of Publications, Bureau of Mines, Washington, D. C. The report covers 26 analyses, including eight crude oils of naphthenic bases, eight which are classed as naphthene-intermediate base and 10 determined as intermediate. The customary Hempel distillation analysis method is followed.

## New Bureau of Mines Petroleum Industry Film

PETROLEUM industry operations, from the location of oil-bearing sands through the drilling of wells, production and storage of oil, transportation, refining and marketing, are shown in a four-reel silent motion picture prepared by the U. S. Bureau of Mines in cooperation with an oil producing company.

The film, "Petroleum—the Liquid Mineral," was photographed at refineries, pipe line systems, natural gas plants, and on oil tank farms. Essential operations are supplemented by animated drawings.

The film is available from the Pittsburgh Experiment Station, U. S. Bureau of Mines, Pittsburgh, Pa., without charge, in either the 16 or the 35 millimeter size The exhibitor pays transportation charges

## API-ASME Code for Unfired Pressure Vessels

THE pressure-vessel problems of the petroleum industry, particularly in petroleum refining where relatively high pressures, high temperatures, and severe corrosion are frequently met, are such as to require special consideration. In order to provide a uniform basis for the construction and maintenance of unfired vessels used in this field, and at the same time not to disturb the uniformity brought about by the codes developed by the ASME Boiler Code Committee, a joint committee of the American Petroleum Institute and The American Society of Mechanical Engineers was organized. This Joint API-ASME Committee on Unfired Pressure Vessels has now completed the first edition of the API-ASME Code for Unfired Pressure Vessels for Petroleum Liquids and Gases which can be obtained from The American Society of Mechanical Engineers, 29 West 39th Street, New York.

The code covers the design, construction, inspection and repair of unfired pressure vessels for petroleum liquids and gases for metal temperatures not over 1000°F and for gage pressures above 15 lb. per sq. in. It is divided into five sections as follows:

W—Design and Construction of Fusion-Welded Vessels.

R—Design and Construction of Riveted Vessels.

F—Design and Construction of Seamless Forged Vessels (in course of preparation.)

I—Inspection, Repair and Allowable Working Pressure of Vessels in Service.

S—Material and Other Specifications.

A special feature of the Joint Code that merits emphasis is its inspection section and its requirement for changing operating conditions to keep stresses at or below those for which the vessel is designed or, as an alternative, removing the vessel from service. It is obvious, therefore, that the code should be used as a whole and that vessels constructed in accordance with the construction sections should be regularly inspected in accordance with the inspection section.

Attention should be called to the fact that the ASME Boiler Code, Section VIII, dealing with unfired pressure vessels has been adopted as the law governing the construction of certain vessels of this type in several states and that consequently vessels within the scope of this section for use in these states must be built in accordance with the Boiler Code rules. The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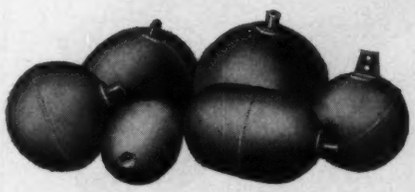

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Joint Code does not have such a legal status.

It is anticipated that many questions will arise with respect to the meaning of parts of the code, and also as to the scope of its application. These questions should be referred to the joint committee whose secretary is R. P. Anderson, 50 West 50th Street, New York. Suggestions for improvement will also be welcomed.

## Gauging Bulletin

TO provide natural gasoline manufacturers and consumers with comprehensive information on the storing and gauging of natural gasoline, the California Natural Gasoline Association announces the publication of Bulletin TS-341, "Tentative Standard Method for Gauging Natural Gasoline in Pressure Storage." Scheduled for adoption soon as a standard procedure by the American Petroleum Institute, the 41-page bulletin represents the results of a cooperative study by nine major natural gasoline producers on the Pacific Coast. The work was coordinated through a committee headed by R. R. Crippon of the Gasoline Division of The Texas Company, California.

Compiled to be of direct use to plant operators and gaugers, as well as engineers, the bulletin provides the details essential to preparing a tank for transfer, the accurate determination of high and low gauges, and the placing of the tank on the line. Complete procedures are included for taking samples and making the necessary tests incidental to accurate measurement. An abridged table of volume correction factors for temperature is given which covers the gravity range of 51° to 89° A. P. I., over the temperature range 0° to 125°F. A suggested form for recording desired data on tank shipments is also included.

Sampling methods include procedures for obtaining representative samples at tank pressure in standardized pressure sample containers. Sampling at atmospheric pressure is also covered. Specific gravity determination includes an abridgment of A. S. T. M. method D287-33 to permit the use of the Chainomatic specific gravity balance. A novel gravity testing device, fitted permanently into the piping system of a tank, is described.

Although the scope of the bulletin does not include the engineering aspects of tank design and construction, specifications for accessories used in measurement are presented to encourage standardized safe practices. Among the many specifications are included maximum gauge glass length, automatic closing gauge fittings, valves, and minimum size of pipe connections. Strapping data are given.

Supplementary to A. P. I. Code No. 25, the bulletin should find a wide distribution. Copies can be obtained through the C. N. G. A. Secretary, 1217 Associated Realty Building, Los Angeles, California, 25 cents postpaid.

## Handbook of Butane-Propane Gases

THE Second Edition of the Handbook of Butane-Propane Gases covers changes in practice and new developments in the industry during the past two years. New contents of the second edition include subject matter on such significant phases, not covered in the first edition, as the use of liquefied petroleum gases in internal combustion engines, design and installation of storage facilities for these gases, engineering data on the lower olefins, manufacture of liquefied petroleum gases at refineries, and the competitive position of these gases.

In view of changing practice, several of the original chapters have been completely rewritten. Among these are the sections on central plants, appliance testing and utilization, and bottled gas distribution.

Other important additions include tables on volume correction factors extending through the propane range, charts on properties of commercial mixtures, bibliography additions covering the extensive literature of the past two years. The revised central plant directory lists the permanent construction camp plants as well as new towns now served. Foreign activity in butane-propane manufacture and sale is also covered in the new handbook.

The new edition is considerably larger than the original one, containing upwards of 400 9 by 12-inch pages and several score new illustrations. Basic reference material from the first edition is retained in the new issue.

The Handbook of Butane-Propane Gases can be secured through the Book Department, Gulf Publishing Company, P. O. Box 2811, Houston, Texas, price $5.00.

## Correction

With reference to the article on "Improved Motor Oils" by Otto, Miller, Blackwood and Davis, reprinted on page 411 of the November, 1934, issue of the REFINER & NATURAL GASOLINE MANUFACTURER, an error of considerable importance occurred.

On page 417, just below Table 3, por-


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tions of two paragraphs were omitted in transcribing the article, with the result that the statements as they appear on that page are entirely different from the statements originally made by the authors.

The statements appearing on page 417 are as follows: "Their flash points and distillation curves are naturally lower than for the equivalent grade mineral oils; but by choice of base which are generally of a stringy nature, and are unstable to heating and to oxidation on account of the highly unsaturated character of the rubber."

The correct statements as they originally appeared in preprint issued by the American Petroleum Institute are as follows: "Their flash points and distillation curves are naturally lower than for the equivalent grade mineral oils; but by choice of base *stocks of proper viscosity, viscosity-index, and flash-point characteristics, entirely satisfactory blends can be made.*

*"These blends should not be confused with soap-thickened oils or other similar blends. Neither should they be classed with mineral-oil blends containing rubber* —which are generally of a stringy nature, and are unstable to heating and to oxidation on account of the highly unsaturated character of the rubber."

## Extension Course in Natural Gas Offered

THE University of Kansas and the American Gas Association have available a home course of study on natural gas. The course covers all phases of natural gas operation from the general considerations of chemistry and physics and the origin of gas and oil, through all of the steps of production, transmission, distribution, to and including utilization. Students are supplied with a text "Natural Gas" in two volumes written especially for the course. The chapters or assignments divide the course into 27 lessons. Students are expected to complete at least one lesson a month, but if desired may send in lessons at shorter intervals. Upon satisfactory completion of the course a certificate is issued.

Although the course does not provide credit toward any university degree, it may be regarded as work equivalent to that which would be required in a five- or six-hour course in engineering. Enrollments will be accepted at any time. Application blanks and further information can be obtained either from the extension division, The University of Kansas, Lawrence, Kansas, or Kurwin R. Boyes, secretary, American Gas Association, 420 Lexington Avenue, New York.

## Institute Committee on Water Transport

CREATION of a Central Committee on Tanker and Barge Transportation to consider subjects relating to the transportation of petroleum and its products by these means has been announced by the American Petroleum Institute.

J. Howard Pew, Sun Oil Company, Philadelphia, who represents the shipping group on the institute's board of directors, has been invited to be chairman ex-officio, it was said by Executive Vice President W. R. Boyd, Jr., who explained that organization of the committee was authorized by the institute's executive committee.

R. F. Hand, Standard Shipping Company, New York, has been invited to become vice chairman, and D. V. Stroop, institute staff engineer, will be secretary. Members of the committee, which will hold an organization meeting shortly, are:

J. V. Blake, The Pure Oil Steamship Company, New York; William Groundwater, Union Oil Company, Los Angeles; A. M. Kelley, Richfield Oil Company, Los Angeles; R. K. Kelly, Tide Water Oil Company, New York; James


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Kennedy, Gulf Refining Company, New York; J. J. Maguire, Socony-Vacuum Oil Company, New York; T. Rieber, The Texas Company, New York; J. K. Robison, Sinclair Navigation Company, New York; J. C. Rohlfs, Standard Oil Company of California, San Francisco; Chris Storey, Cities Service Transportation Company, New York; R. C. Tuttle, The Atlantic Refining Company, Philadelphia; A. O. Woll, General Petroleum Corporation, Los Angeles; and G. D. Zeh, Associated Oil Company, San Francisco.

## Gard Addresses C.N.G.A. Meeting

SPEAKING before the December meeting of the California Natural Gasoline Association, C. D. Gard of Union Oil Company read a paper on "Natural Gasoline Measurement with a Displacement Meter." The presentation dealt with a new metering device for measuring large volumes of natural gasoline without recourse to gauging or orifice meter reading. Well illustrated, the paper revealed how the meter should be calibrated and lubricated. The scope of its application was compared to that of the orifice meter.

On the same program, H. M. Stilley of Firestone Tire & Rubber Company discussed rbber in its application to tires, as well as to the manufacture of gaskets and hose for the petroleum industry.

Printed copies of these papers, together with a stenotyped transcription of the floor discussion, are available to non-members for 50 cents postpaid, through the secretary, 1217 Associated Realty Building, Los Angeles.

## Dr. Curme Is Presented Perkin Medal

THE Perkin Medal of the Society of Chemical Industry, a distinguished honor among chemists, was presented January 11, to Dr. George O. Curme, Jr. of Carbide & Carbon Chemicals Corporation. The occasion was a joint meeting of the Society of Chemical Industry, the American Chemical Society, the Electrochemical Society and the Societe de Chimie Industrielle, held at The Chemists' Club, 52 east 41st Street, New York City.

The award of the medal was made several months ago by a committee representing five national chemical societies. This medal is awarded annually for valuable work in applied chemistry and Dr. Curme was chosen for his work on the development of commercial processes for synthesis of aliphatic organic compounds such as alcohol, acetone and ethylene glycol.

The first speaker on the program of the meeting was Dr. E. R. Weidlein of Mellon Institute who outlined Dr. Curme's accomplishments. Presentation of the medal followed, Dr. Marston T. Bogert of Columbia University, a past president of the Society of Chemical Industry, making the presentation. Dr. Curme then presented his medal address, which was entitled "Industry's Toolmaker."

George O. Curme, Jr. was born in Mt. Vernon, Iowa, December 24, 1888. He graduated from Northwestern University in 1909, spent one year at Harvard University in graduate study, and received the degree of Doctor of Philosophy at the University of Chicago in 1913. He then spent a year as a graduate student at the University of Berlin under Emil Fischer. In 1914 he accepted a fellowship at the Mellon Institute of Industrial Research at Pittsburgh, to investigate synthesis of acetylene and olefine gases and their chemical derivatives. This work was continued on an expanding scale until 1920, when the project was transferred to a semi-


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plant scale near Charleston, West Virginia. In 1920 Carbide and Carbon Chemicals Corporation was organized to exploit the results of the earlier research and to continue the commercial development of organic synthesis. Dr. Curme was named chief chemist of this company in 1920, vice president and director of research in 1929. During his period of service with the company successful processes have been developed and put into commercial operation for synthetic production of ethylene glycol, acetone, ethyl alcohol, methyl alcohol, butyl alcohol, acetic anhydrite, glycol ethers, triethanolamine and related products many of them derived from petroleum. This work has, in effect, created a new division of industrial chemistry based on the synthesis of aliphatic chemicals, which has become an important factor in American industry.

## Changes in Board Standard of Indiana

REVISION of the directorate of Standard Oil Company, (Indiana), effective January 1 included resignation of Dr. R. E. Wilson who was appointed vice chairman of the board of directors of Pan American Petrolem & Transport Company, a subsidiary, and the naming of Harry F. Glair, general manager of manufacture as a new director.

Both men have been given broad recognition in the refining industry and are authorities in that field. Recently Dr. Wilson has devoted much time to special business transactions and has assumed other phases of executive management as a director of the company and his appointment to the vice chairmanship of the board in the large subsidiary concern simply calls for a further expansion of these duties. He will move to the company's offices in New York and will assume his duties as active head of Pan American Petroleum & Transport Company.

Some of the duties Dr. Wilson has been handling will be taken over by Bruce K. Brown, manager of the development and patent department, others by Dr. F. W. Sullivan, who is to be transferred from the Whiting research laboratories to become general research director in the main office.

Harry F. Glair, the new director began work with Standard Oil Company (Indiana) at the Whiting refinery in 1906. After taking time off to complete a course in mechancal engineering in the University of Illinois with the class of 1912, he advanced from the drafting room through a series of executive positions until he became manager of the plant in the period from 1929 to 1931. He was transferred to Chicago in August, 1931, as assistant general manager of manufacturing and was promoted to general manager in January, 1933.

**HARRY F. GLAIR**

## California Association Announces New Directorate

FOLLOWING a revision of the by-laws of the California Natural Gasoline Association changes were announced in the directorate of the association and the following are now listed as directors in their respective classes:

Active Class "A," J. A. Campbell, Lomita Gasoline Corporation; F. E. Davie, Shell Oil Company; H. L. Eggleston, Gilmore Oil Company (ex-officio); O. C. Field, O. C. Field Gasoline Corporation; R. D. Gibbs, Union Oil Company; R. W Heath, Signal Oil & Gas Company; B. A. Koehler, Getty-Pacific Western Oil Company; H. R. Linhoff, Richfield Oil Company; N. H. Mull, Texas Company; W. N. Roper, Western States Gasoline Corporation; T. L. Taggart, Standard Gasoline Company (ex-officio); R. C. Wheeler, General Petroleum Corporation.

Active Class "B," W. Moeller, Jr., Southern California Gas Company; H. N. Wade, Parkhill-Wade, Inc.

Active Class "C," W. A. Kirk, California Southern Oil Company.

Active Class "D," P. E. Fluor, Fluor Consolidated Company; J. R. Hoffman, Smith-Booth-Usher Company.

## Collett Chairman of P. & C. Committee

J. D. COLLETT was elected, December 18, Chairman of the Planning and Coordination Committee to succeed Judge Amos L. Beaty, who has tendered his resignation. The committee also voted to submit to the Cole Investigating Committee a proposed bill. It is understood that the bill will include "quotas in commerce" provisions and also authorization for interstate compacts.

## Natural Gasoline Supply Men's Association Elections

PAUL M. RAIGORODSKY, president of Petroleum Engineering, Inc., Tulsa, Oklahoma, was chosen president of the Natural Gasoline Supply Men's Association at the annual election of officers held by the directors of the organization December 28. He succeeds B. W. Vinson.

Other officers elected at the same meeting were: E. H. Triphaus, Southwestern regional division manager for Taylor Instrument Company, Tulsa, first vice president; G. B. Lane, southwestern district manager for the Foxboro Company, Dallas, second vice president; J. A. Lupfer, vice president and general manager, Worthington Machinery Corporation of Oklahoma, treasurer; and W. F. Lowe, Secretary.

J. H. Satterwhite, Westcott & Greis, Inc., Tulsa, is the retiring vice president, and M. H. Kotzebue, Tulsa

**PAUL M. RAIGORODSKY**

Boiler & Machinery Company, Tulsa, the retiring treasurer.

Committee reports of the past year's activities indicated that the association had had one of its most successful years in history both from a financial and program standpoint. Plans for 1935 were discussed and a meeting is to be held early in the year to appoint committees for carrying out a comprehensive program.

## Six Socony-Vacuum Officials Retired

WITH terms of service averaging 41 years, six executives of Socony-Vacuum Oil Company, retired at the end of 1934. The veterans are terminating their long service voluntarily, on pension.

The men had been with the company from 33 to 48 years. William J. Higgs, former errand boy for John D. Rockefeller, Sr., in the early days of the petroleum industry, possessed the longest record with the company. He had been active since 1887.

The retiring officials are Charles W. Hadley, chairman of the manufacturing committee of the corporation; F. H. Fitzgerald, director of Standard-Vacuum Oil Company, in charge of lubrication sales; Ernst Michaelson, executive of Socony-Vacuum's European organization; H. C. Cornforth, chairman of the board of Vacuum Oil Company, Pty. Ltd., of Melbourne, Australia; W. L. Lever, manager of the order and shipping department of Standard-Vacuum Oil Company, and Mr. Higgs, assistant treasurer of Socony-Vacuum Oil Company, Inc.

The six men had been closely identified with the growth of the company, and are retiring with the regrets of the management.

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E. P. ANGUS, pioneer oil man and one of the most widely known marketing executives in the Southwest, retired as vice president and manager of sales of Magnolia Petroleum Company on December 31.

"Mr. Angus, while still a comparatively young man, has completed 38 years of service in the petroleum industry and is now eligible for optional retirement under the company plan," Mr. Little, president of the company, said. "His contribution to the development of the oil business in the southwest has been a constructive one and he has been one of the outstanding marketing executives in our industry. While no longer an active member of the organization, we shall continue to claim Mr. Angus as a member of the Magnolia family."

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H. T. KLEIN of The Texas Company, has been re-elected chairman of the American Petroleum Industries Committee for 1935. E. S. Hall of Standard Oil Company of New Jersey has been re-elected secretary. Baird H. Markham continues as director.

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FRED J. WALLAS, who recently became a member of the development and research staff of The International Nickel Company, Inc., addressed the Buffalo, New York, chapter of the American Society for Metals, December 18 at the Hotel Buffalo. He discussed metallurgy in an elementary way and included data on the improvement of physical properties of cast irons, steels and other metals obtained by the addition of various alloying elements.

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D. A. NEMSER, metallurgist, development and research department, The International Nickel Company, was the guest speaker at the December 7 meeting of the Boston chapter of the American Society for Metals (formerly American Society for Steel Treating). He introduced his talk with a resume of various types of alloy steels, outlining briefly methods of production, effects of alloying elements and methods of inspection and later gave emphasis to those steels used in large quantities by various manufacturers.

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DR. O. B. J. Fraser, superintendent of technical service for The International Nickel Company, Inc., delivered an address December 19 before the Washington (D. C.) Society of engineers in which he discussed "Corrosion from a General Engineering Standpoint." Fraser formerly was in charge of the company's laboratory research where he had opportunity to study closely the corrosion problem.

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WILBUR F. BURT has been appointed chairman of the manufacturing committee of Socony-Vacuum Oil Company, succeeding Charles W. Hadley, who retires from that position on January 1, after 44 years' service. Burt started his career with the company directly after his graduation from Amherst College in 1912. He entered the employ of Standard Oil Company of New York as a coal mixer in a refinery. Later he became a fire-


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Working in various departments, he subsequently was appointed general superintendent of the paint and cooperage division. He also assumed management of the Safety and Claims departments, until he became vice chairman of the manufacturing committee of Standard Oil Company of New York. In 1929 he was appointed chairman of the committee. Following the merger of Standard Oil Company of New York and Vacuum Oil Company into Socony-Vacuum Oil Company, he became vice chairman of the manufacturing committee for the company.

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HOWARD H. DELLINGER, of the general laboratories of Socony-Vacuum Oil Company, New York, has been transferred to the Atlas refinery at Buffalo, to take charge of the laboratory at that refinery.

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W. R. BOROUGH has been appointed general superintendent for McClanahan Refineries, Inc., at its new refinery at St. Louis, Michigan. Mr. Borough was formerly with The Texas Company, operating several of that company's refineries in various states.

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DR. GUSTAV EGLOFF of Universal Oil Products Company addressed the faculty and students of the University of Wisconsin, Dec. 20 on the subject "Newer Products from Petroleum." On December 11, Dr. Egloff spoke at the University of Minnesota on "Science in the Production of Gasoline and Motor Oil."

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G. L. FARNED, formerly superintendent of Humble Oil & Refining Company's Ingleside, Texas, refinery, has been made superintendent of the company's Baytown, Texas, plant. F. N. Read, formerly superintendent of the Baytown plant has been transferred to the Ingleside refinery as superintendent. At Baytown, Mr. Farned is working under the supervision of R. E. Powell, general manager of the refinery.

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L. A. MEKLER, combustion engineer for Universal Products Company, addressed the Chicago section of the American Institute of Mining and Metallurgical Engineers at the Engineers Club, on December 20. The subject of his talk was temperature and corrosion-resistant alloys for the petroleum industry, emphasizing cracking tube materials.

## Gas Measurement Short Course Committee Plans

THE annual reorganization meeting of the General Committee for the Southwestern Gas Measurement Short Course was held recently in the Oklahoma Utilities Association offices in Oklahoma City, with D. C. Williams of Ponca City, general chairman in charge.

New members of the committee for the 1935 short course are B. P. Stockwell of the Oklahoma Corporation Commission, Oklahoma City; William F. Lowe of Tulsa, secretary of Natural Gasoline Association of America; J. H. Satterwhite, Tulsa, American Meter Company; Earl Kightlinger, Shreveport, Arkansas Natural Gas Corporation. John H. Baxter of Inland Gas Company, Ashland, Kentucky, who was identified actively with the short course during the first two years of its history, was added to the ex-officio membership comprised of past general chairmen.

Chairmen of sub-committees are the following: banquet, entertainment and arrangements, W. H. Carson, Norman; program, R. D. Turner, Tulsa; exhibits, G. W. McCollough, Bartlesville; registration, E. F. McKay, Oklahoma City; study of


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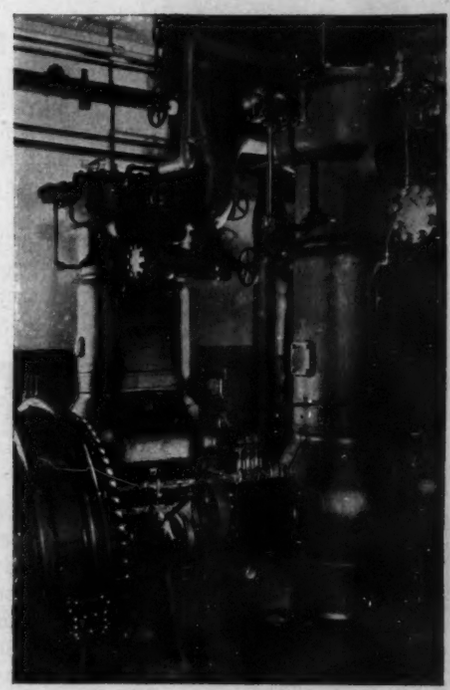

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practical methods, Ray Roundtree, Houston, Texas; and publications, Max Watson, Amarillo, Texas.

The General Committee will hold a meeting in January to decide dates for the 1935 course, to be held, as usual, at University of Oklahoma, Norman.

## Indiana Standard Appoints New Medical Director

APPOINTMENT of Dr. Bryce B. Reeve, Whiting, Indiana, as director of the medical department of Standard Oil Company (Indiana) to succeed the late Dr. Frank R. Morton was announced January 2. Dr. Reeve joined the organization as assistant surgeon of the refinery hospital at Whiting on April 23, 1923, and became chief surgeon there a few months later. He has since served in that capacity and as assistant to Dr. Morton.

He will direct the extensive operations through which Standard Oil Company (Indiana) guards against accidents and lost time through illness by careful preliminary examinations of all applicants for positions, watchfulness over health of employees, prompt attention to injuries, and scientific determination of time for retirement. Two hospitals, several first aid stations, and a considerable staff of consulting physicians are under his supervision.

## Natural Gasoline Association Meeting Plans

THE Natural Gasoline Association of America recently announced the dates for its 1935 annual meeting as May 1, 2 and 3. The meetings are to be held in the Tulsa Hotel in Tulsa and are to include the usual group meetings for technical and marketing membership. Subjects will be announced later. Ray Miller, vice president of Hanlon-Buchanan, Inc., is chairman of the program committee and members of the committee are as follows: J. W. Vaiden, Skelly Oil Company; S. S. Smith, Shell Petroleum Corporation; H. L. Eggleston, Gilmore Oil Company Los Angeles, president of California Natural Gasoline Association; J. B. Atkins, Parade Gasoline Company, and R. N. Parks, Virginia Gas & Gasoline Company.

## Gray Process In Roumania

INSTALLATION by Creditul Minier of the Gray process for clay treating of cracked gasoline, in Roumania, is proceeding in accordance with arrangements recently completed between the two companies. The Creditul Minier installation is licensed in connection with its new (Dubbs) cracking unit. The process is regarded as superior to acid treatment of cracked gasoline in the preservation of octane rating and conservation of material treated while reducing gum content to minimum. Negotiated with the Gray Processes Corporation through its Roumanian agent, Herman Bensmann, the Creditul license is understood to be for a lump sum commuted fee, payable in monthly installments over an extended period.

From the standpoint of such operations in Roumania, the Creditul installation marks the second Gray plant to be licensed. The towers of Steaua Romana, at Campina, have been in operation since 1930. Subsequently Gray's licensing situation in Roumania as elsewhere has been improved by arrangements effected in 1933, whereby The Gray Processes Corporation licenses not only the Gray process, but also the R. K. Stratford (Imperial Oil) slurry clay treating method, the Osterstrom liquid phase method, and other clay treating developments of The Pure Oil Company, Standard Oil Company (Indiana), Standard Oil Development Company and The Texas Company.

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## ▼ PLANT ACTIVITES ▼

**Gas Plant:** Gas-Oil Products, Inc., Philadelphia, is erecting a plant for manufacture of liquefied gases at Lucinda, Philadelphia. Contract to Burrell-Mase Engineering Company.

**Recovery Plant:** Republic Oil Company, Texas City, Texas, is erecting a new absorption type vapor recovery plant. Contract to Burrell-Mase Engineering Company.

**Stabilizer:** Empire Oil Company at Burrton, Kansas, is erecting a new stabilization system. Contract to Burrell-Mase Engineering Company.

**Refinery:** Premier Oil Refining Company, Longview, Texas, has completed plans for the erection of a 2500-barrel skimming and cracking plant in Gregg County, East Texas oil field. Site has been purchased near the I. & G. N. Railroad between Kilgore and Longview. Officers of the company are J. R. Parten, president of Woodley Petroleum Company, Houston, chairman of the board; Sylvester Dayson, president; Sam W. Ross, Kilgore, and R. A. Stacy, an official of the Delta Drilling Company, Longview, vice presidents; and Richard Blalock, Marshall, secretary-treasurer. Other members of the board and stockholders include wealthy royalty owners in the field.

**Carbon Black:** United Carbon Company, Amarillo, Texas, is reported contemplating erection of a 50,000,000 cubic foot capacity carbon black plant in Hutchinson County, Texas Panhandle, using residue gas from the F. C. Henderson Gasoline Company's gasoline plant near Sanford.

**Storage Plant:** Colonial Beacon Oil Company, Niskayuna, New York, will build bulk storage plant, warehouse, tankage, office and pump house. To cost approximately $85,000.

**River Terminal:** Sun Oil Company, at Cincinnati, Ohio, will build landing facilities on the Ohio river here for unloading gasoline from barges, and a six-inch pipe line to storage tanks.

**Asphalt Plant:** Standard Oil Company, East Providence, R. I., is planning erection of a one-story asphalt processing plant here to be leased to American Bitumuls Company, 229 Broadway Place, Everett, Mass. Estimated cost $75,000.

**Storage Plant:** Intra-Coastal Petroleum Company, Lake Arthur, Louisiana, has started construction of an oil storage plant with capacity of approximately 1,000,000 gallons of oil and gasoline. C. J. Dick, Galveston, Texas, president.

**Refinery:** Emmert & Emmert, Corpus Christi, Texas, reported planning an oil refinery, using its own forces. Some new equipment is to be purchased. Estimated cost $75,000.

**Refinery:** Phoenix Refining Company, San Antonio, Texas, has started operating its 800-barrel skimming plant completed in mid-December in the Condor-Sayles field, Jones County, Texas, seven miles north of Abilene.

**Refinery:** Compania de Petroles de Mexico, S. A. (Petromex) a new Mexican government sponsored concern is reported in position to start operations. Plans call for drilling for production first and later construction and operation of a refinery and facilities for distribution of products.

**Refinery:** Consumers Refineries Cooperative Association, Regina, Saskatchewan, Canada, has announced plans for construction of a small skimming


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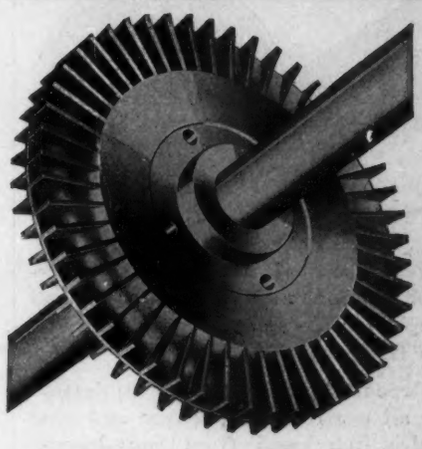

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plant near the town of Regina to be in operation in the spring.

**Carbon Black Plant:** Paramount Natural Gasoline Company (Danciger interests) has applied to Texas Railroad Commission for permit to erect carbon black plant near its natural gasoline plant, Pledger, Texas, (near Houston.) Hearing to be held early in January.

**Refinery:** Capitol Oil & Refining Company, Cheyenne, Wyoming, plans to build a small refinery in which it will process Osage crude. J. S. Higgins, organized the company.

**Carbonization:** Two more plants for the low temperature carbonization of coals as planned in France, at Lieven and Bethune, following successful work of the original plant at Lens which went into operation last July. The new plans have been approved by the Minister of Labor and the municipalities affected and work is to start at once, at an estimated cost of 40,000,000 francs.

**Treating Towers:** Creditul Minier, Roumania, is installing the Gray process for clay treating of cracked gasoline in accordance with arrangements recently completed between the two companies. The process is licensed in connection with Creditul Minier's new Dubb cracking unit.

**Refinery:** Zuila Refining Company, A. Goldman and others, is erecting a 2000-barrel skimming plant on the Crabtree and Jeffries' Giles lease, Pru survey, Rusk County, East Texas field.

**Refinery:** W. L. Barclay and S. J. Holt, Wichita Falls, Texas, are building a small skimming plant on the Payne property five miles southwest of Wichita Falls on the Seymour highway.

**Gasoline Plant:** Apex Gasoline Company is nearing completion of its new natural gasoline plant in Section 17, Porter Township, Midland County, Michigan.

**Improvements:** Roosevelt Oil Company, Mount Pleasant, Michigan, has completed additions to its steam plant through installation of two additional boilers.

**Purchase:** Buckeye Natural Gasoline Corporation, Pittsburgh, has purchased through receivership sale the 21,000,000 cubic foot natural gasoline plant erected seven years ago in the Shamrock field, Wheeler County, Texas Panhandle, by Phelps Gasoline Company.

**Improvements:** The Pierce Oil Company, S. A. at Tampico, Mexico, is building a 1200-barrel topping unit similar to the unit installed at this plant last year. An asphalt reducing unit at the same plant is nearing completion.

**Receivership:** Ouachita Valley Refining Company, El Dorado, Arkansas, was placed in receivership late in December by Federal Judge Ragon at Fort Smith upon petition of Sklar Oil Corporation of East Texas. C. L. Crenshaw, refinery superintendent and R. C. Knox, attorney for the refining company, were named receivers, and will continue operations.

**Refinery:** Herbert Green & Company, Ltd., London England, previously reported in these columns as building a complete lubricating oil refinery at East Halton, Iincolnshire, England, has awarded contract to The Lummus Company for construction of facilities including a Duo-Sol plant and contact filtration and dewaxing plants.

**Refinery:** Administracion Nacional de Combustibles, Alcohol y Portland Gerencia, of Montevideo, Uruguay, South America, previously reported planning erection of topping plant, cracking unit, debutanizing plant, treating system, steam plant, and auxiliaries for refining, has let contract to Foster Wheeler, Ltd. of England, who will take charge of erection of the plant for the government.

**Russian Plants:** Soviet Russia plans construction of 93 cracking units and 48 topping plants in that country during the next three years. Extraction of gasoline from peat under conditions that make large scale production practical also was announced recently stating also that such motor fuel is better than gasoline and produced at half the cost.

**Cracking Unit:** Naph-Sol Refining Company, Muskegon, Michigan, W. E. Anderson president, has signed license agreement with Universal Oil Products Company, and will start erecting a full flashing type Dubbs cracking unit with charging capacity of 1000 barrels daily. Contract has been signed for sale of


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cracked gases to West Michigan Company, a manufacturer and distributor of gas. The unit will be erected by Universal Oil Products Company engineers.

**Shale Oil:** The board of control of Estonia's shale oil industry at a recent meeting discussed plans for the extension and enlargement of the shale oil industry's crude oil and gasoline producing plants in Estonia.

**Enlargement:** Curacaosche Petroleum Industrie Maatschappij (Shell Oil Company) will spend 12,000,000 florins (gold) during 1935 and 1936 enlarging the refinery at Curacao. Among other works, the plan includes the addition of 50 or 60 storage tanks.

**Dismantling:** Texas Petroleum Products Company, Somerset, Texas, is dismantling its 1500-barrel skimming and cracking plant and will no longer engage in refining.

**Modernizing:** Shell Oil Company at its Dominguez Hill gasoline plant, California, has completed modernization of pumping and other equipment with work under contract to Industrial Engineers, Inc.

**Refinery:** Los Angeles Refining Company, recently organized with Glenn Dies as manager, is erecting a 2000-barrel tube still type skimming plant on Bandini Boulevard, Los Angeles.

## Filtrol Company Represents Gray Processes Corporation

The Filtrol Company of California, under arrangements recently completed, becomes licensing agent for Gray Processes Corporation of Newark, New Jersey. Three processes, each involving the use of fine clay, will be dealt with by the licensor. Included are the Stratford process, the Osterstrom Vapor Phase process, and the Hill-Baylis process now under development.

The new arrangement does not apply to the Gray process or to the Osterstrom liquid phase clay treating process, and represented as heretofore by present agents, Alco Products Incorporated and The M. W. Kellogg Company, both of New York.

Development and exploitation of the three processes for which The Filtrol Company will be licensor is expected to proceed along lines related naturally to the development of clays of types adapted to the processes. Licensees will be under no obligation to use a particular brand of clay, but may employ any suitable fine clay in line with the requirements of their installation.

**Worthington Pump & Machinery Corporation** has recently established a Pacific Coast regional headquarters in Los Angeles, which will center jurisdiction and development of the corporation's business in the western area now included in the coverage of the company's offices in Seattle, San Francisco, Los Angeles, and El Paso. C. E. Wilson, vice president, is in charge of the new office and has moved his office from New York to the new headquarters at 510 West 6th Street, Los Angeles. In 1923, after previous connections with the company for some years, Wilson was made general sales manager and in 1932 was elected a vice president.

**The Brown Instrument Company,** Philadelphia, has announced a consolidation with Minneapolis-Honeywell Regulator Company, Minneapolis, Minnesota. The Brown Instrument Company will continue as a separate company with its existing organization but as a subsidiary of Minneapolis-Honeywell Regulator Company. Richard P. Brown will continue as president of The Brown Instrument Company and will become an officer and director of Minneapolis-Honeywell Regulator Company. The Brown Instrument Company sales and service facilities will be continued from the present main office and factory at Philadelphia and the district offices located throughout the country.

**Paul W. Gregory** has been appointed general manager of the Canton Culvert Company, Canton, Ohio, a subsidiary of Republic Steel Corporation. Gregory succeeds F. A. Kelly, who was recently appointed president of Toncan Culvert Manufacturers Association, Youngstown, Ohio, and head of Republic Steel Corporation's culvert division.

**General Refractories Company,** Philadelphia, announces appointment of Collinwood Shale Brick & Supply Company, Cleveland, Ohio, as dealer-agents in the Cleveland area. The distributors will carry a complete stock of refractories.

**Directors of the Blaw-Knox Company,** December 21, elected Robert F. McCloskey, director and vice president in charge of operations of the plants located at Blawnox, Pennsylvania, to replace Wayne Rawley, deceased. McCloskey formerly was general superintendent of the company's Blawnox shops and has been associated with the company since 1920.

**The Borden Company,** Warren Ohio, has changed its corporate name to Beaver Pipe Tools, Inc., and this change in corporate name is designed to identify the name of the company with the name of its products, for the convenience of its customers. The company began its thirty-fifth year in pipe tool manufacture in January.

**The Ernest E. Lee Company,** 53 West Jackson Boulevard, Chicago, has been appointed by Coppus Engineering Corporation, to handle Coppus air filters for air compressors, internal combustion engines, industrial and ventilating applications in the Chicago territory.

## Donovan to Head A. P. I. Safety Committee

GEORGE A. HILL, JR., chairman of the general committee of the Division of Production of the American Petroleum Institute, has announced appointment of the Committee on Accident Prevention for 1935. R. E. Donovan, Standard Oil Company of California, has been appointed chairman, and H. N. Blakeslee, American Petroleum Institute, was re-elected secretary of the committee. Donovan's headquarters are in San Francisco, while Blakeslee is located in the Kirby Building, Dallas, Texas.

Other members of the committee include the following: C. P. Anderson, Richfield Oil Company of California, Los Angeles; H. W. Boggess, Sinclair Prairie Oil Company, Tulsa; A. W. Breeland, Lone Star Gas Company, Dallas; John Hammermann, Jr., Gulf Production Company, Houston; H. J. Hanlon, Standard Pipe Line Company of Louisiana, Shreveport; C. L. Hightower, United Gas Company, Houston; L. R. Hodell, Carter Oil Company, Tulsa.

H. W. Jackson, Kendall Refining Company, Bradford, Pa.; G. O. Lockwood, The Empire Companies, Bartlesville, Okla.; J. L. Manes, Sun Oil Company, Dallas; C. H. Martin, Phillips Petroleum Company, Bartlesville; M. C. McDowell, Rio Bravo Oil Company, Houston; George F. Prussing, Union Oil Company of California, Los Angeles.

H. C. Renz, Atlantic Oil Producing Company, Dallas; J. L. Risinger, Magnolia Petroleum Company, Dallas; R. B. Roaper, Humble Oil & Refining Company, Houston; C. W. Smith, Standard Oil Company (Indiana), Chicago; Cabanne Smith, Houston Oil Company, Houston; J. P. Sutton, Ohio Oil Company, Findlay, Ohio; C. R. Weidner, Sinclair Prairie Pipe Line Company, Independence, Kan.

Charles Fitzgerald, Sinclair Prairie Pipe Line Company of Texas, Fort Worth, Texas, has been appointed an alternate for C. R. Weidner.

# SCIENCE AND TECHNOLOGY

*Abstracts prepared in co-operation with the*

**REFINER AND NATURAL GASOLINE MANUFACTURER**

*by*

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*under the supervision of*

**DR. E. H. LESLIE and DR. H. B. COATS**

*The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.*

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## Fundamental Physical Data

**Phase Equilibria in Hydrocarbon Systems. V.** B. H. SAGE, J. G. SCHAAFSMA AND W. N. LACEY. *Ind. Eng. Chem.* **26** (1934) pp. 1218-24.

Published pressure volume temperature data on propane are few and are limited to the properties of the saturated liquid and saturated vapor at temperatures below 125°F. and to some divergent values of vapor pressure and critical temperature. Heat of vaporization and specific heat under saturated conditions have been studied up to 90°F., and the specific heat at constant pressure of 1 atmosphere and at temperatures up to the boiling point of water. The authors have conducted an extended study of the properties of propane from atmospheric pressure to 3000 pounds per square inch and at temperatures from 70°F. to 220°F. A new variable volume cell was designed and constructed to study any sample of hydrocarbon mixture of constant mass and composition. The data secured are presented in tabular and graphical form and constitute a valuable addition to knowledge of the thermodynamic properties of propane.

## Chemical Composition and Reactions

**Specific Refractive Dispersion as a Method for Distinguishing Between Different Series of Hydrocarbons.** A. L. WARD AND W. H. FULWEILER. *Ind. Eng Chem., Anal. Ed.* **6** (134) pp. 396-400.

The authors state that it has been their experience that the combination of physical and chemical methods is best for the analysis of hydrocarbon mixtures. Among the physical methods proposed is one employing specific refractive dispersion. Dispersion is the difference in refractive indices determined for light of two different wave lengths. Specific dispersion is dispersion divided by density, both constants being determined at the same temperature. As employed in this paper, the specific dispersion is the number calculated as above multiplied by $10^4$. Data on numerous hydrocarbons are presented and the possibilities for the use of specific dispersion are discussed. It is concluded that the method will be useful in confirming or denying conclusions from other methods.

**The Thermal Decomposition of Organic Compounds from the Standpoint of Radicals. X. The Identification of Methyl Groups as Dimethyl Ditelluride.** F. O. RICE AND A. L. GLASEBROOK. *Jour Am. Chem. Soc.* **56** (1934) pp. 2472.

All of the numerous methods that have been used for the identification of the fragments produced in thermal decomposition of organic compounds suffer from the drawback that the primary products formed by combination with the free radical cannot be separated readily from the excess of organic compounds and thus identified, but must first be converted into some other compounds having more suitable properties. It was therefore deemed advantageous to find a substance that would combine with free radicals to give a compound that could be readily separated from the excess of the original substratum and could be easily identified. Metallic tellurium was found to be an almost ideal substance for this purpose. A compound is formed between methyl groups and tellurium. The compound is a deep red liquid that is comparatively stable in air, insoluble in water but soluble in common organic solvents. It was found that methyl groups are the only fragments that escape from the furnace when butane, acetone or diethyl ether are decomposed at low pressures in the range from 800 to 900°C.

**Thallium Alkyls and Aryls.** S. F. BIRCH. *J. C. S.* (1934) pp. 1132-1136.

Thallium alkyl compounds were studied with reference to their value as anti-knock materials. These compounds were prepared by the action of lithium alkyls on dialkylthallium bromide, the reaction being effected in solution in benzene and under an atmosphere of nitrogen. Triphenyl thallium crystallizes in white needles, melts at 188-9°C., and decomposes at 215-216°C. It is soluble in benzene but insoluble in light petroleum. Triethylthallium is a yellowish liquid that fumes in moist air and boils at 50-51°C. at 1.5 mm. pressure. It decomposes upon heating into thallium and butane. Triisobutylthallium is a liquid boiling at 74-76°C. at 1.6 mm. pressure. It was found that the thallium alkyls add only approximately one-tenth to the anti-knock value of tetraethyl lead.

**The Activated Adsorption of Hydrocarbons.** J. TURKEVICH AND H. S. TAYLOR. *Jour. Am. Chem. Soc.* **56** (1934) pp. 2254-2259.

The adsorption of ethylene as a typical unsaturated hydrocarbon, and methane, ethane and propane as saturated hydrocarbons, was studied in relation to typical hydrogenating catalysts. When using manganese oxide-chromium oxide catalysts, studies were made in the temperature range from —78.5 to 444°C. The adsorption characteristics and decomposition products of ethylene on active copper were determined in the same temperature range. The experimental observations led to a concept of the surface gas system in accord with knowledge of various catalytic reactions on such surfaces. The conditions for exchange reaction between deuterium and ethylene or ethane are also defined by the adsorption measurements.

**Cyclic Components of Paraffin Wax.** J. MULLER AND S. PILAT. *Nature,* 134 (1934) p. 459.

Successive crystallization from pyridine and ether, and finally from benzene, separated the bulk of paraffin wax into four fractions; (1) m 76°, corresponding to the proportion of C and H of $C_nH_{2n+2}$, (2) m. 63°. $C_nH_{2n}$, (3) m. 57°, $C_nH_{2n-2}$, (4) m. 50°, $C_nH_{2n-8}$. The I number of the first fraction was 5. The slope in the temperature-viscosity curve, the increase in specific gravity from 0.798 to 0.817 at 80°, and in $n\frac{80}{D}$ from 1.4470 to 1.4558 with progressive decreases in the C:H ratio suggest the cyclic constitution of these hydrocarbons.

## Manufacture: Processes and Plant

**Design of Cooler Condensers for Mixtures of Vapors with Non-condensing Gases.** A. P. COLBURN AND O. A. HOUGEN. *Ind. Eng. Chem.* **26** (1934) pp. 1178-82.

In the condensation of vapor from mixtures of vapor with non-condensible gas, the gas film and overall heat transmission coefficients vary widely from point to point in the apparatus. Also the change in heat content of the gaseous mixture is not proportional to the change in temperature; therefore no simple relationship expressing the mean temperature difference between the gas vapor and the cooling water

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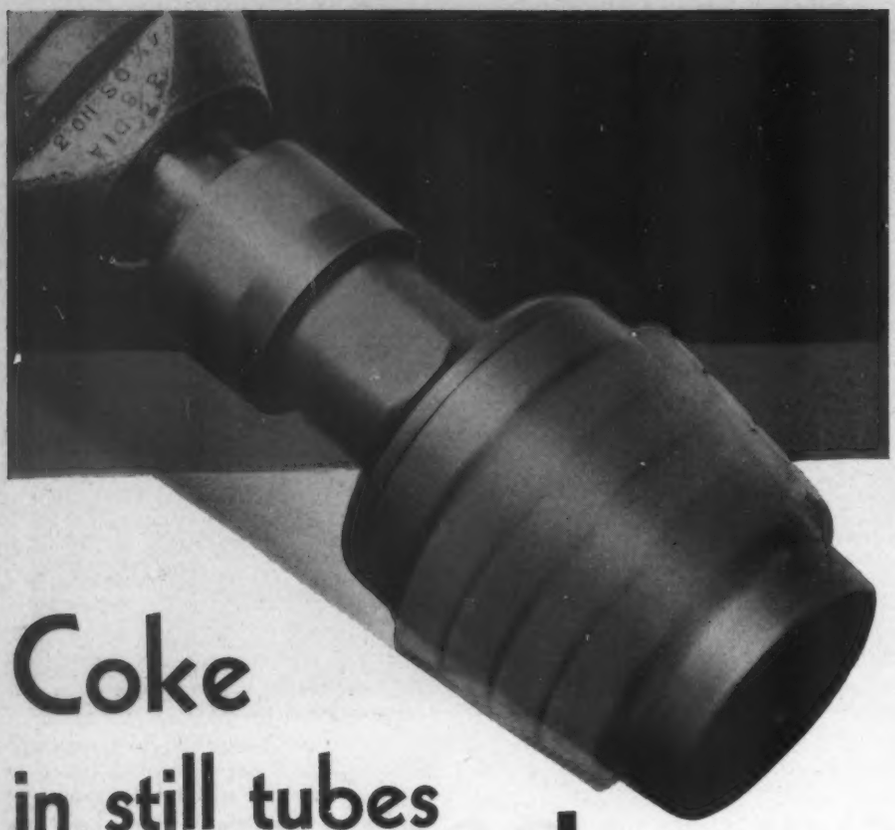

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stream can be used. The paper outlines a method of computing the required condenser surface by determination of the value of $\frac{1}{U\Delta t}$ at a sufficient number of points along the path of gas flow to permit calculation of a correct average value of $U\Delta t$ by graphical integration. The value of $U\Delta t$ at any point in the condenser is obtained through trial and error by equating the heat transferred through the condensate, the tube wall and the cooling water film to the sum of the heat transferred by the sensible cooling of the uncondensed gas and the latent heat equivalent of the vapor transferred by diffusion and condensed. Coefficients for the transfer of vapor are estimated on the basis of a correlation previously published. An example illustrating the procedure is presented. In this the overall coefficient U varies from 294 to 60, whereas the effective heat transmission coefficient of the condensing vapor gas film varies from 5600 to 75. The authors comment upon the faulty design used in calculating some standard equipment, such as that used in cooling artificial or coke oven gas. The surfaces used are eight to 10 times those actually required if the apparatus is properly designed.

**Mass Transfer (Absorption) Coefficients.** T. H. CHILTON AND A. P. COLBURN. *Ind. Eng. Chem.* **26** (1934) pp. 1183-87.

In the design of apparatus to effect diffusional processes such as dehumidification or partial condensation, evaporation of a liquid into a gas, drying of solids in the initial state, absorption of gas by a liquid, and rectification, it is necessary to have a means of estimating the rate of transfer of the diffusing component per unit of size of the apparatus considered. There has been a great need for a convenient method of applying the well substantiated correlations from the analogous processes of fluid friction and heat transfer to test the diffusion data available and to permit prediction where there are no applicable data. One of the authors previously suggested that a set of curves proposed for estimating heat transfer coefficients by means of a "heat transfer factor" could also be used for estimating coefficients for the transfer of material by diffusion. It is shown in the present paper that these curves predict values of mass transfer coefficients in close agreement with data for flow inside tubes taken from the works of several authors.

**Creep Properties of Oil-Still Tubes.** HOWARD C. CROSS AND E. R. JOHNSON. *Iron Age* **134**, No. 8 (1934) pp. 16-21, 68.

The materials to be tested were taken from finished oil-still tubes. With steel containing 4-6% of chromium and 0.50% of molybdenum, an increase in the carbon content from 0.139 to 0.181% resulted in an improvement in physical properties and in resistance to creep. Longitudinal material showed better creep resistance than transverse material. The creep properties of slow cooled material are better than those of normalized materials. Slow cooling resulted in uniform structure with well defined grain, whereas the normalized and reheated materials of comparable hardness showed less uniform structures. Resistance to impact was lower for transverse materials than for longitudinal materials. Specimens subjected to load and temperature for one thousand hours revealed no notable drop in toughness as shown by the impact test.

**Static Electricity as a Fire Cause.** E. E. TURKINGTON. *Quart. Natl. Fire Protect. Assoc.* **28** (1934) pp. 16-25.

Many unusual examples of discharges of static electricity are cited. In one case crude oil flow-

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ing through a two-inch pipe at high velocity and discharging with a clear drop of 20 feet produced discharges up to four feet in length. Experiences with the discharge of carbon dioxide from cylinders and with the handling of rubber cement are cited. Grounding, humidity control to maintain over 40% relative humidity, and ionization are discussed as preventives. Analysis of a fire record of 147 static produced fires is shown to be seasonal and in rough inverse ratio to relative humidity.

**Specifications for a System of Bituminous Pipe-Line Protection.** ULRIC B. BRAY AND F. S. SCOTT. *Gas Age-Record* **74** (1934) pp. 33-7.

The more important specifications of the Union Oil Company of California for the protection of pipe lines are: (1) the pipes shall be thoroughly cleaned with wire brush and kerosene, or with a sand blast; (2) a priming solution is sprayed on and allowed to dry; (3) a sling coat of sealing asphalt is applied at 375°F.; (4) an asphalt with mineral filler coat is applied at 425°F.; (5) a butt-joined spiral wrapper is applied; (6) a flood coat of asphalt and mineral filler is applied; and (7) if the soil is clay or adobe, a second wrapper coat is applied and followed with an exterior asphalt and filler coat.

**Modern Methods of Purifying Boiler Feed-Water.** K. HOFER. *Stahl u. Eisen,* **54** (1934) pp. 701-708, 729-731.

The paper describes boiler water purification by means of trisodium phosphate and colloidal solutions, the effects of various softening compounds on corrosion in the boiler, methods of producing protective films, procedures for removing dissolved gases, methods for removing colloidal material that causes foaming. The avoidance of caustic embrittlement is discussed, as well as the effects of various details of construction of the boiler itself; the prevention of scale formation in condensers is also discussed.

## Products: Properties and Utilization

**Gasoline Survey for 1933.** H. McD CHANTLER. *Can. Dept. Mines, Mines Branch Rep.* **746** (1934) 21 pp.

One hundred and seventeen samples of gasoline were collected in 15 cities in August, 1933, and the results of analyses of these gasolines are given. The variation in quality was less than in any previous year. Ninety percent of the gasoline had knock ratings higher than 56. The average Reid bomb vapor pressure was 6.9 pounds per square inch, which was a decrease of 0.5 pounds from the 1932 average. All samples had less than 10 pounds vapor pressure. Ninety-two percent of the gasoline contained less than 10 milligrams of gum per 100 cc. Only one gasoline gave a positive corrosion test with a copper strip.

**Further Experiments on Cylinder Wear.** C. G. WILLIAMS. *J. I. A. E.,* **2** (1934) pp. 19-34.

These studies were made for the purpose of determining the causes of the accelerated wear occuring at low engine temperatures. Gasoline containing 0.03 to 0.20% of sulphur was studied and it was concluded that the sulphur content of high grade gasolines has no important relation to cylinder wear at low temperatures, but that gasoline containing more than 0.1% of sulphur markedly accelerates cylinder wear. To determine the effect of nitrogen oxide formed during combustion, the nitrogen normally present in the fuel-air mixture was replaced by carbon dioxide The result was a large increase in cylinder and piston wear. That carbon dioxide and water are responsible for some, but not all, of the wear was confirmed in experiments in which hydrogen was used as fuel and in others in which carbon dioxide was added to the intake air in some of the hydrogen experiments. The effect of nitric and organic acids was not directly determined, although the results in general suggest that some wear is caused by either or both of these acids. In an effort to determine the effect of organic acids, tests were made with alcohol blend fuel. Cylinder wear increased 80% and top ring wear by 100% over that characteristic of ordinary gasoline. Wear at high operating temperatures is in any case less than that at temperatures below the dew point of the combustion product. High temperature wear is probably caused by abrasion. The results indicate that cylinder wear at normal operating temperatures is largely independent of oil consumption and is not reduced by upper cylinder lubricants. The latter, however, are beneficial at lower operating temperatures. But this benefit can also be had by increasing the supply of crankcase oil to the cylinder walls. The value of upper cylinder lubricants is increased by the addition of oleic acid. This confirms previous work with crankcase oils containing oleic acid, which oil was used under low engine temperature conditions.

**A Method for the Determination of the Alcohol Content and Water Tolerance of Alcohol-Petrol Blends.** W. R. ORMANDY, T. W. M. POND AND W. R. DAVIES. *Jour. Inst. Pet. Tech.* **20** (1934) pp. 913-35.

The authors describe a method for determining the alcohol content by volume and the residual water tolerance in cc. per gallon for any alcohol-gasoline blend. The method depends upon the addition of a standard excess of water to given volumes of the blend, thus causing separation after agitation. The alcohol-rich layer is measured. In each case the alcohol content is determined by the residual water tolerance. The apparatus is described, as well as the graphical work required for the establishment from the data of the complete residual water tolerance. The effect of temperature and benzol are discussed. It is noted that much of the criticism previously leveled against alcohol-gasoline blends was centered on the likelihood of separation into two layers. This criticism may have been justified when only 95% alcohol was available. Now, however, low cost dehydration has made 99.5% alcohol commercially available, and the criticism loses most of its force. Blends now on the market have a generous margin of safety, and with their increasing use it has become a matter of greater importance to be able to determine this margin with ease and accuracy.

**Refrigerating Practice with Reference to Lubrication.** J. K. L. WEBLING. *Refrigerating Eng.* **28** (1934) pp. 185-7.

Lubricating oil is not affected by carbon dioxide. Ammonia has only a slight action occasioned by combination with naphthenic acids present in the oil. This may cause some turbidity. It is therefore practical to choose an oil for use with these gases that is similar to average air-compressor oil. Sulphur dioxide has a slight action on the less stable components of the oil and, over a period of time, may produce tarry substances. This necessitates the use of specially refined oils. Methyl chloride is miscible in all proportions with lubricating oil, and therefore oils of high viscosity must be used with this refrigerant.

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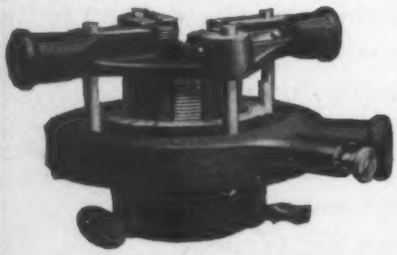

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**A Method of Evaluating the Viscosity-Temperature Characteristics of Oils.** W. M. McCluer and M. R. Fenske. *Ind. Eng. Chem., Anal, Ed.* **6** (1934) pp. 389-92.

The authors point out that seven means for evaluating and comparing oils with respect to their relative rates of change of viscosity with temperature are available. These are the ratio of 100°F. to the 210°F. viscosity, the viscosity index as developed by Dean and Davis, the viscosity slope number as developed by Bell and Sharp, the viscosity gradient devised by Clayden, the viscosity-gravity constant introduced by Hill and Coats, the viscosity gravity zone as recommended by Larson and Schwaderer, and the gravity index based on an empirical relationship between viscosity-gravity constants and viscosity index. None of these methods results in a quantitative expression of actual viscosity at low or high temperatures. The present paper outlines a method by means of which viscosities of different oils may be compared quantitatively either at low temperature, as encountered in winter starting, or at high temperature, as encountered in motor operation.

**Indiana Oxidation Test for Motor Oils.** T. H. Rogers and B. H. Shoemaker. *Ind. Eng. Chem., Anal. Ed.* **6** (1934) pp. 419-20.

In view of the general interest in the Indiana oxidation test, the authors describe it in detail. This test measures the length of time (sludging time) until rapid formation of asphaltenes begins, as indicated by the asphaltene content of 10 milligrams per 100 grams of oil. In addition, as a measure of the rate of sludging, the time required to form a larger amount of sludge (100 milligrams per 10 grams of oil) is determined. Motor oils vary widely in their oxidation stability from 10 to 15 up to several hundred hours sludging time. Those of lighter grade have, in general, lower stabilities than the heavier grades. For oils that have little or no tendency to form asphaltenes, it is desirable to measure the rate of viscosity increase, for which the test procedure also makes provision. In general, for oils having a sludging time above approximately 100 hours, the determination of the viscosity increase becomes more significant than determination of sludging time and sludging rate.

**Adhesion of Oils to Metallic Balls.** Louis, Zwicky and Berbain. *Ann. des Comb. Liquides,* **6** (1934) pp. 585-595.

At constant temperature the weight of an oil adhering to polished steel balls is proportional to the surface and to the viscosity. Where two balls touch, there is a ring of oil retained at the point of contact, the weight of which is a linear function of the diameter and is not affected by viscosity. The results indicate that the compounding of mineral and vegetable oils will result in a thicker adhering film. The ring of oil between two balls should serve as a reservoir of lubricant, and the use of small balls should therefore be advantageous.

**Application of Fractional Diffusion to the Analysis of Vaseline Oil.** E. Andre and A. Bloch. *Ann. des Comb. Liq.,* **9** (1934) pp. 489-497.

A petrolatum oil was separated into a number of fractions by the use of acetone as a solvent. Three main groups of hydrocarbon components of decreasing solubility in acetone have been isolated. Mean molecular weight of these fractions corresponds to $C_{19}H_{39}$, $C_{28}H_{58}$ and $C_{35}H_{68}$. The middle fraction contains optically active components. It was thought that the hydrocarbon cholestane may be present. A confirmation of this would be of interest in connection with the origin of petroleum.

**Packing Material for Fractionating Columns.** M. R. Fenske, C. O. Tongberg and D. Quiggle. *Ind. Eng. Chem.* **26** (1934) pp. 1169-77.

The authors studied the efficiency of packings for fractionating columns. Five different systems were distilled, namely, carbon tetrachloride and benzene, benzene and toluene, normal heptane and toluene, normal heptane and methylcyclohexane, and acetone and methanol. To determine the effect of height and diameter of the column, 11 different fractionating columns were used. Many different packing materials were studied, including wire helices, glass helices, crimped wires, carding teeth, double-cross wire forms, Lessing rings, glass tubes, cut tacks, shot, rivets and several types of jack chain. The data secured are presented in tabular form. The authors reach the conclusion that the best packings are one-turn and two-turn wire helices, one-turn and two-turn glass helices, carding teeth, and No. 19 jack chain. An increase in height reduces the efficiency of the packing; an increase in the diameter of the column reduces the efficiency of the packing. Difierent hydrocarbon mixtures give approximately the same H.E.T.F. value.

**Efficient Small-Scale Fractionating Equipment.** C. O. Tongberg, D. Quiggle and M. R. Fenske. *Ind. Eng. Chem.* **26** (1934) pp. 1213-17.

The authors describe two small fractionating columns, one of glass for the distillation of a 50 to 100 cc. charge, and the other of nickel for an 11 liter charge. The columns were tested with binary mixtures of several types. Rates of distillation and reflux ratios were determined. It was found that the H.E.T.P. did not vary signicantly for various hydrocarbon solutions. It is noted that the performance of a column should not be judged by the flatness of the boiling point curve but by some independent method of analysis of the distillate such as the determination of refractive index or density.

**Analysis of Gaseous Hydrocarbons. A Method for Determining Ethylene, Propylene, and Butene.** H. Tropsch and W. S. Mattox. *Ind. Eng. Chem., Anal. Ed.* **6** (1934) pp. 404-5.

The analysis of mixtures of unsaturated gaseous hydrocarbons has progressed from methods in which all unsaturateds were absorbed by strong sulfuric acid or bromine water, to a method depending on fractional solution in which isobutene is absorbed in 63 to 68% sulfuric acid, propene and n-butenes by 87% acid, and ethylene in concentrated acid but with the addition of catalytic agents. Separation of the gaseous olefins by fractional solution in sulfuric acid has the definite limitation that normal butenes cannot be separated from propenes. Methods involving a combination of low temperature fractional distillation with selective sulfuric acid absorption require relatively large

samples and are tedious and time consuming. The method here described is dependent upon the fractional solution of propene and butene in 87% sulfuric acid, the density of the mixture of propene and butene serving to give the index or ratio of the two olefins. The accuracy of the method has been verified by the analysis of carefully prepared synthetic mixtures. Application of the method to the analysis of refinery gases has shown it to be suitable for rapid routine analyses.

**Analysis of Gaseous Hydrocarbons. Determination of the Gasoline content of Gases.** H. TROPSCH AND W. S. MATTOX. *Ind. Eng. Chem., Anal. Ed.* **6** (1934) pp. 405-8.

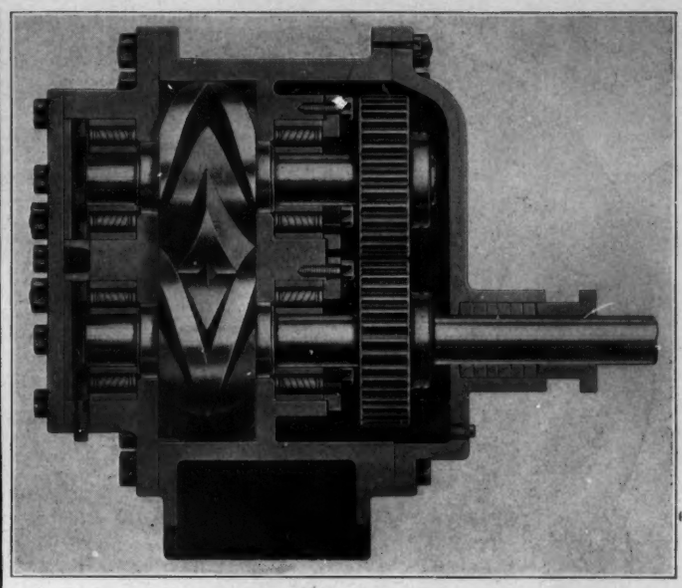
The methods described for the determination of the gasoline content of gases consist in condensing the hydrocarbons at the temperature of liquid nitrogen (—195°C.) and atmospheric pressure, removing methane and other difficultly condensible gases, especially dissolved nitrogen, under reduced pressure, and then fractionating the hydrocarbons at low pressure in a U-tube cooled to 105°C., the temperature at which hydrocarbons above $C_4$ are condensed. The hydrocarbons $C_5$ and higher are then vaporized into a known volume where the pressure and temperature can be measured. The gasoline vapors are condensed by liquid nitrogen in a bulb that is removed from the apparatus and weighed. From the weight of gasoline and the pressure exerted when vaporized in a known volume at definite temperature, the average molecular weight of the gasoline is calculated. From a curve relating the molecular weight to the specific gravities of the pure hydrocarbons, the specific gravity of the gasoline is read. With the weight of gasoline from a known volume of gas and the specific gravity of the gasoline, the gallons of gasoline per one thousand cubic feet of wet gas can be calculated. It is stated that the method is applicable to the analysis of a wide variety of refinery gases, and that it is rapid and suitable for routine purposes.

**Apparatus for Boiling Point and Boiling Range Measurements.** D. QUIGGLE, C. O. TONGBORG AND M. R. FENSKE. *Ind. Eng. Chem., Anal. Ed.* **6** (1934) pp. 466-8.

The authors describe an apparatus that permits taking not only equilibrium initial boiling points but also successive boiling points as material is distilled from the apparatus, thereby enabling the use of the boiling point spread as an indication of the purity of the material examined. The apparatus is similar to that developed by Cottrell. A side tube is added that permits any quantity of material to be distilled, so that boiling points can be taken at any given percent removed. The apparatus can also be used for the calibration of thermocouples or thermometers and for the determination of vapor pressures, and also for the determination of molecular weight by the method of boiling point elevation.

**An Evaporation Rate Method Applied to Petroleum Thinners.** D. D. RUBEK AND G. W. DAHL. *Ind. Eng. Chem., Anal. Ed.* 6 (1934) pp. 421-2.

Methods for expressing the volatilities of solvents and thinners depend upon plotting the loss of weight of solvents against time of evaporation. The authors describe an improvement in the apparatus for this test. An ordinary friction top can lid is used with a piece of high grade filter paper cut to fit the bottom of the pan and held down by a weighted tripod. Using this procedure, chemically pure benzene is a straight line evaporation curve.

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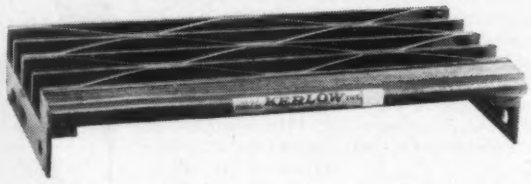

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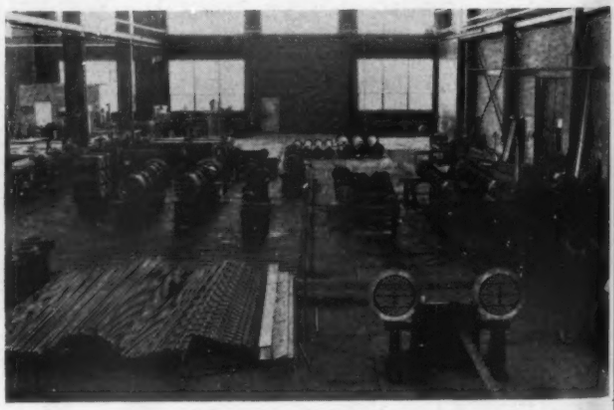

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**BAILEY METER COMPANY**

Bailey Meter Company, Cleveland, Ohio, announces a new meter to indicate and record both boiler water level and feed water flow, for use in boiler plants where it is desired to have both an indication and record of these factors on the operating floor.

This combination meter consists of a Bailey fluid meter which indicates, records and integrates feed water flow and a 12-inch indicator with a dial type scale for boiler water level. The indicator is mounted directly above the recording meter on a small feed water panel.

For purposes of comparison, it is valuable to have the records of feed water flow and boiler water level recorded on the same chart where they are coordinated as to time and can be interpreted easily without reference to additional records or calculations. Boiler water level being a factor which should be frequently checked by the operators, it is shown on the 12-inch indicator so that the exact position of water in the boiler drum may be easily determined by a glance at the indicating pointer. A permanent record of boiler water level definitely shows water level changes which took place within the boiler drum.

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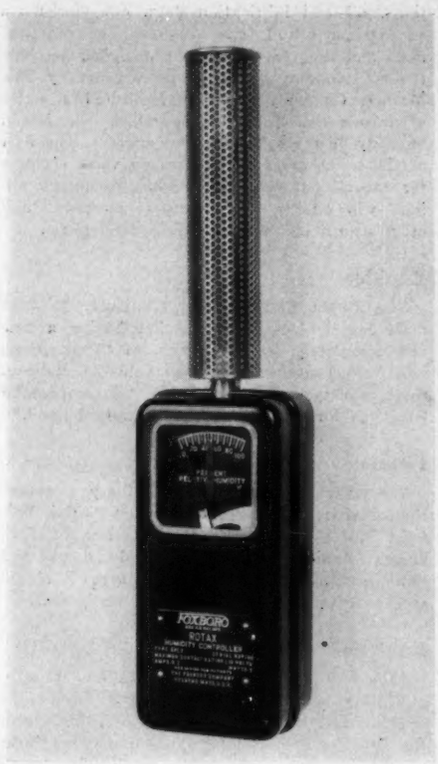



*Foxboro Humidity Controller*

## Humidity Controller

**THE FOXBORO COMPANY**

The Foxboro Company, Foxboro, Mass., has combined for the first time in its newly developed Rotax, indicating relative humidity controller and the company's accurate membrane type of relative humidity measuring element withits Rotax type of electrical control contacts. The controller can be located conveniently wherever electric current is available. It maintains humidity simply and easily, it is said, by operating solenoid valves and motor valves on water, air, or steam lines. Its range is from 0 to 100 percent relative humidity, and it is designed for use between 10° and 120° F.

## Diesel Engine

**INGERSOLL-RAND COMPANY**

Ingersoll-Rand Company, 11 Broadway, New York, is producing a stationary-type Diesel engine. This unit is of the four cycle, single-acting, solid-injection type. It has a box-type housing, cylinder lines, and an overhead chain-driven camshaft, and is fully inclosed and provided with automatic lubrication throughout. The I.-R. Diesel engine is built in sizes ranging from 175 to 1500 bhp. and is applicable for direct-connected alternating-current generator drive, gearing to pumps, direct-connection to compressors, for belting to line shafting and for similar work.

## Chart for Expansion Loops

**TUBE-TURNS, INC.**

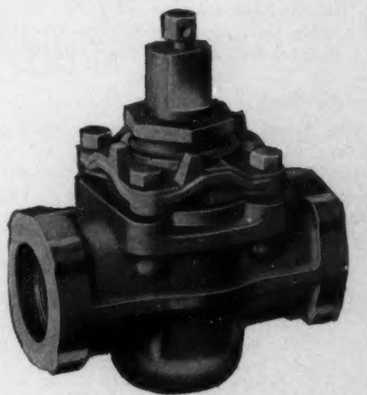
Tube-Turns, Inc., Herald Post Building, Louisville, Kentucky, announces availability of a quick reference chart which provides a simple method of designing expansion loops, using Tube-Turns and straight lengths of pipe or tubing. Expansion loops of this construction are highly efficient and have been proven thoroughly practical under a wide range of pressure and temperature applications. This chart, based on the most modern bending theory, enables the engineer, without going into involved calculations, to quickly lay out efficient, dependable loops that will meet almost any space requirement. Suitable loops may be designed by varying the length of pipe at the top of the loop or of the side legs, depending upon construction limitations.

All results given by the chart include an ample safety factor and maximum fibre stress in loops so designed will not exceed 16,000 pounds per square inch, the generally accepted maximum safe working stress for low-carbon steel pipe.

## Lubricated Plug Valves

**MERCO NORDSTROM VALVE COMPANY**

Merco Nordstrom Valve Company, subsidiary of Pittsburgh Equitable Meter Company, announce a redesigned line of semi-steel, 500-pound working pressure, Nordstrom lubricated plug valves. These valves can be furnished in sizes from ½ to 4-inch, inclusive, wrench operated, having either flange or screw connections. In the latter case Briggs standard thread, A. P. I. line pipe thread or A. P. I. tubing thread can be supplied. Lowered prices, made possible by the change in design, have been placed on these valves.



*500-Pound Nordstrom Lubricated Plug Valve*

# CATALOGS . . . BULLETINS

## *Helpful Publications Which Manufacturers Will Be Glad to Send Free for the Asking*

### Turbines

Elliott Company, Jeannette, Pa., has issued a new bulletin describing its type AY and BY mechanical drive turbines, improved types which were introduced a couple of years ago. The description is concise but complete; the bulletin is illustrated with views and section through the turbine, overspeed governor, steam chest and speed governor.

### Equipment

Sun Shipbuilding & Dry Dock Company, Chester, Pa., is distributing a four-page bulletin describing its built-to-order refinery equipment, giving details of service rendered in the field of plant equipment fabrication.

### Pumps

Byron Jackson Company, Berkeley, California, is distributing Bulletin No. 357-11-34, describing its line of Hydropress vertical multistage pumps, for hot oil service in refineries, boiler feed service, for lifts up to 10,000 feet and for pressures to 2800 pounds.

### Pyrometers

Thwing Instrument Company, 3339 Lancaster Avenue, Philadelphia, is distributing Leaflet A-3410, describing that company's line of small and multiple pyrometers, for such work as Diesel engine exhaust temperatures and for general industrial applications.

### Control

The Bristol Company, Waterbury, Conn., is distributing Bulletin No. 424, "Bristol's metameter for telemetering pressure, liquid level, temperature, flow and motion with a simple two-wire circuit. Engineering principles of this remote control are presented in the discussion.

### Chemicals

Monsanto Chemical Company, St. Louis, Mo., has issued "How Monsanto Serves," an attractive 24-page bulletin discussing operations of the company together with the application of a wide variety of its products. The bulletin is completed with a list of Monsanto chemicals.

### Lubrication

The Merriam Company, 1955 West 112th Street, Cleveland, Ohio, announces a new pamphlet jointly prepared by The Meriam Company and the engineers of Socony-Vacuum Oil Company, which containes operating instructions, oil and lubrication data, etc., for users of Meriam rebuilt gas enignes. The practical facts and diagrams given are designed also for the assistance of gas engine users generally. The Meriam Company has also instituted a series of informative postal cards which are issued monthly on the subject of gas engines. The first of the series gives useful data on valve settings for natural gas operation, and subsequent mailings will deal with lubrication problems and other useful information. Free on request.

### Booklets

The Linde Air Products Company, 30 East 42nd Street, New York, is distributing a new and completely revised edition of "Precautions and Safe Practice." Another valuable addition to oxy-acetylene literature is "Recommended Practices for Gas Cutting of Structural Steel."

### Pumps

Worthington Pump and Machinery Corporation, Harrison, New Jersey, is distributing bulletin W-318-B6, dealing with its line of two-stage volute type U, centrifugal pumps and bulletin W-317-B2 dealing with type F single stage volute centrifugal pumping equipment.

### Engines

Elliott Company, Jeannette, Pa., has recently published a 32-page bulletin, B-3 on Elliott engines and engine-generator units, indicating the field for the different types of engines built by the company such as the single-valve, four-valve, Corliss valve unaflow and poppet valve unaflow engines. Each type is described as are the principles of operation.

### Sheet Iron Primer

Republic Steel Corporation, Massilon, Ohio, is distributing "Sheet Iron—A Primer," Bulletin 127. The book contains 64 pages and In simple non-technical language it tells the step-by-step story of modern manufacture of sheet iron, tracing production from the ore mine to the final inspection of the completed sheet. It contains gauge tables and an interesting glossary of metallurgical terms.

### Diesel Engines

Ingersoll-Rand Company, 11 Broadway, New York, has recently issued a catalog describing its stationary type Diesel engine. The unit is of the four-cycle, single acting, solid injection type. The bulletin includes all pertinent engineering information.

### Cable

General Electric Company, Schnectady, N. Y., is distributing "Industrial Cable" a 128-page book describing all standard types of insulated wire cable used by industry for transmission, distribution and control. The publication is companion to the company's 80-page book on "How to Select Insulated Cable."

### Belting

Chicago Belting Company, 113 North Green Street, Chicago, is distributing a leaflet on leather belting for short center drives.

### Blowers

Roots-Connersville Blower Corporation, Connersville, Indiana, has issued Bulletin 22-23 B10, illustrating and describing its standard heavy-duty types of blowers, including discussion of characteristics, operating principles, and typical installation views.

### Electric Equipment

General Electric Company, Schenectady, N. Y., is distributing Bulletin GEA-1137 B, Indoor A-CO cubicle switchgear; bulletin GEA 1585 A-, High voltage oil immersed magnetic switches, and Bulletin GEA-1327 A- Indoor disconnecting switches.

### Hydrometers

H.B. Instrument Company, 2518 N. Broad Street, Philadelphia, has issued Blue Book, Part 2, listing a full line of Hydrometers. This well illustrated book is divided into sub-headings, according to the industry that uses a particular group of hydrometers.

### Chemicals

Carbide & Carbon Chemicals Corporation 30, East 42nd Street, New York, has issued a 77-page summary of synthetic organic chemical products of this company, with data, specifications and descriptions of all products.

### Chemicals

Southern Alkali Corporation, Corpus Christi Texas, has issued a 16-page booklet describing the location, markets and products of this company.

### Steels

U. S. Steel Corporation, Pittsburgh, Pa., has issued an eight-page bulletin dealing with chemical and physical properties of various high tensile steels, including a brief discussion of shop practices and a summary of the advantages of these steels.

### Diesel Engines

De La Vergne Engine Company, Philadelphia, has issued five new bulletins, Nos. 51 to 55, inclusive and No. 58, describing the full line of Diesels. Engines are all four-cycle, full Diesel, solid injection, and range from 2000 r.p.m., 200 h.p. to 200 r.p.m. and 1600 h.p. detailed specifications included.

### Traps

J. E. Swendeman, Inc., 171 Camden Street, Boston, Mass, is distributing a four-page bulletin describing multi-gravity traps which will handle water, oil or any two or more liquids of varying specific gravity coming from after-coolers, receivers or other apparatus.

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